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MALCOLM PIRNIE

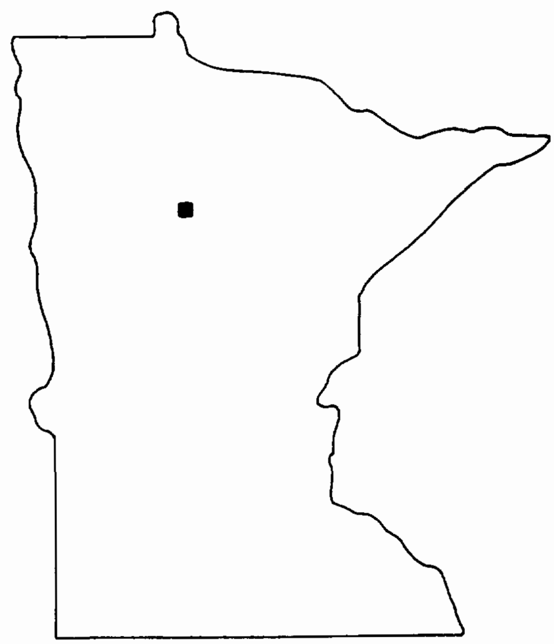
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

960732

REMEDIAL INVESTIGATION FINAL REPORT

FOR

KUMMER SANITARY LANDFILL



NORTHERN TOWNSHIP
BELTRAMI COUNTY, MINNESOTA

MINNESOTA POLLUTION CONTROL AGENCY

APRIL, 1988

0871-03-6015

REMEDIAL INVESTIGATION FINAL REPORT

KUMMER SANITARY LANDFILL

MINNESOTA POLLUTION CONTROL AGENCY

APRIL 1988
0871-03-6

MALCOLM PIRNIE, INC.

Environmental Engineers, Scientists and Planners
5001 West 80th Street, Suite 770
Minneapolis, MN 55437

KUMMER SANITARY LANDFILL
REMEDIAL INVESTIGATION FINAL REPORT

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1.0 INTRODUCTION

1.1 GENERAL

This section of the Remedial Investigation Draft Report for the Kummer Sanitary Landfill describes the site location, provides a historical background of the problem, explains the steps in which the remedial investigation was conducted and summarizes the scope of the total report.

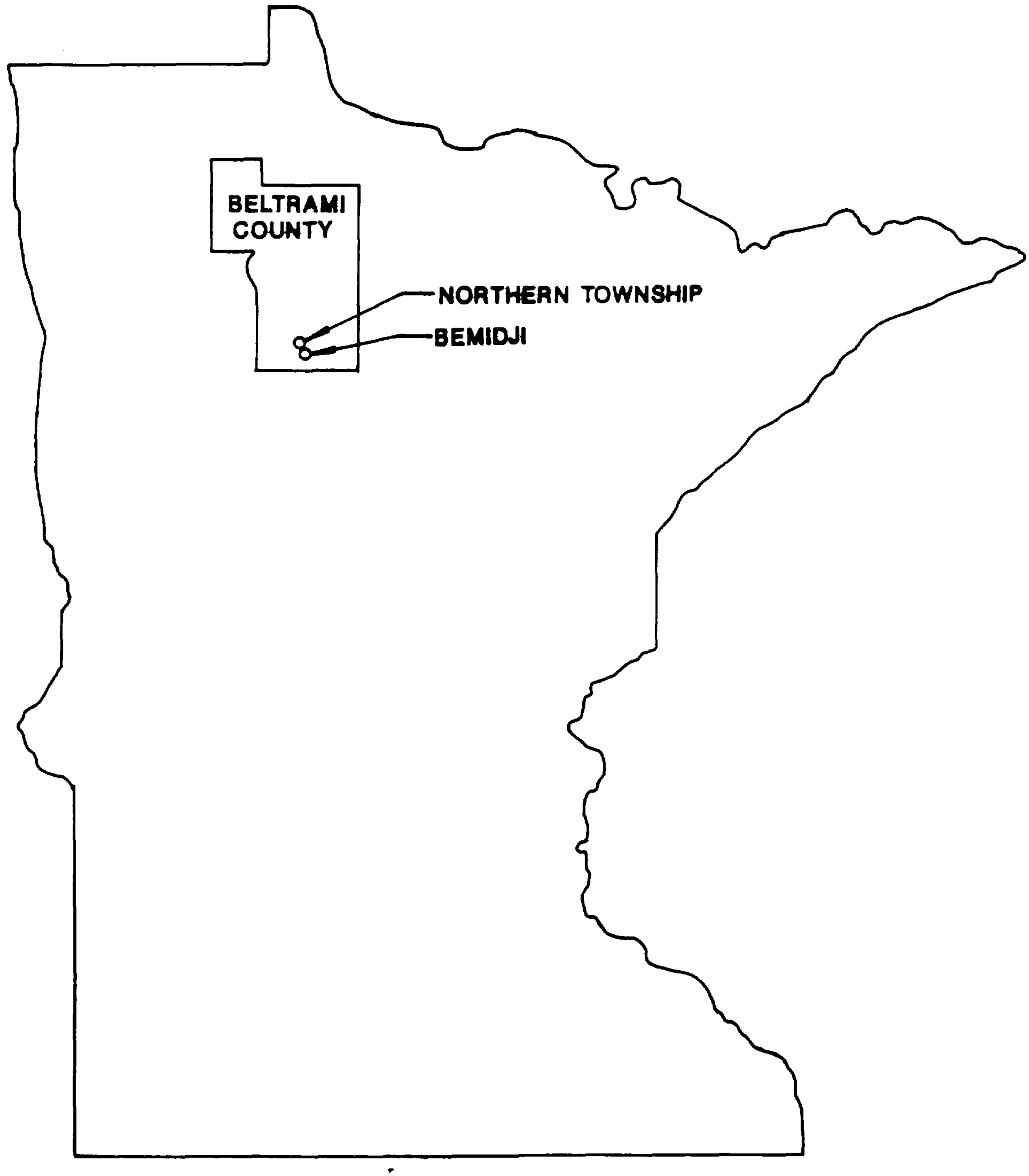
1.2 SITE LOCATION

The Kummer Sanitary Landfill is located in Northern Township, Beltrami County, Minnesota. Figure 1-1 shows the location of Northern Township and Beltrami County. The site is approximately one mile west of Lake Bemidji along the north side of Anne Street, N.W., midway between Highways U.S.71 and County State Aid Highway 15. The northern corporate limits of the City of Bemidji are one-half mile south of the site. The landfill location is shown on Figure 1-2.

1.3 BACKGROUND

The Minnesota Pollution Control Agency (MPCA) issued Permit SW-31 to construct and operate the landfill to Mr. Charles Kummer on April 26, 1971. Successive stages of landfill development are shown on Figures 1-3, 1-4 and 1-5. The sketches were developed using data from aerial photography, surface photography, site operation reports, MPCA site inspection reports, and conversations with MPCA personnel. The primary source of information for the sketches was a set of black and white aerial photographs acquired from private companies, as well as state, county, and local agencies. One or more photographs were obtained for each of the following years: 1969, 1972, 1974, 1976, 1979, 1981, 1982, 1983, and 1985.

Each sketch shows the landfill as it appeared at a given time. Areas of disturbance are outlined in heavy black lines on each sketch in which are shown active fill areas, previously filled areas, and borrow areas. Approximately 200 color slides



MALCOLM PIRNIE

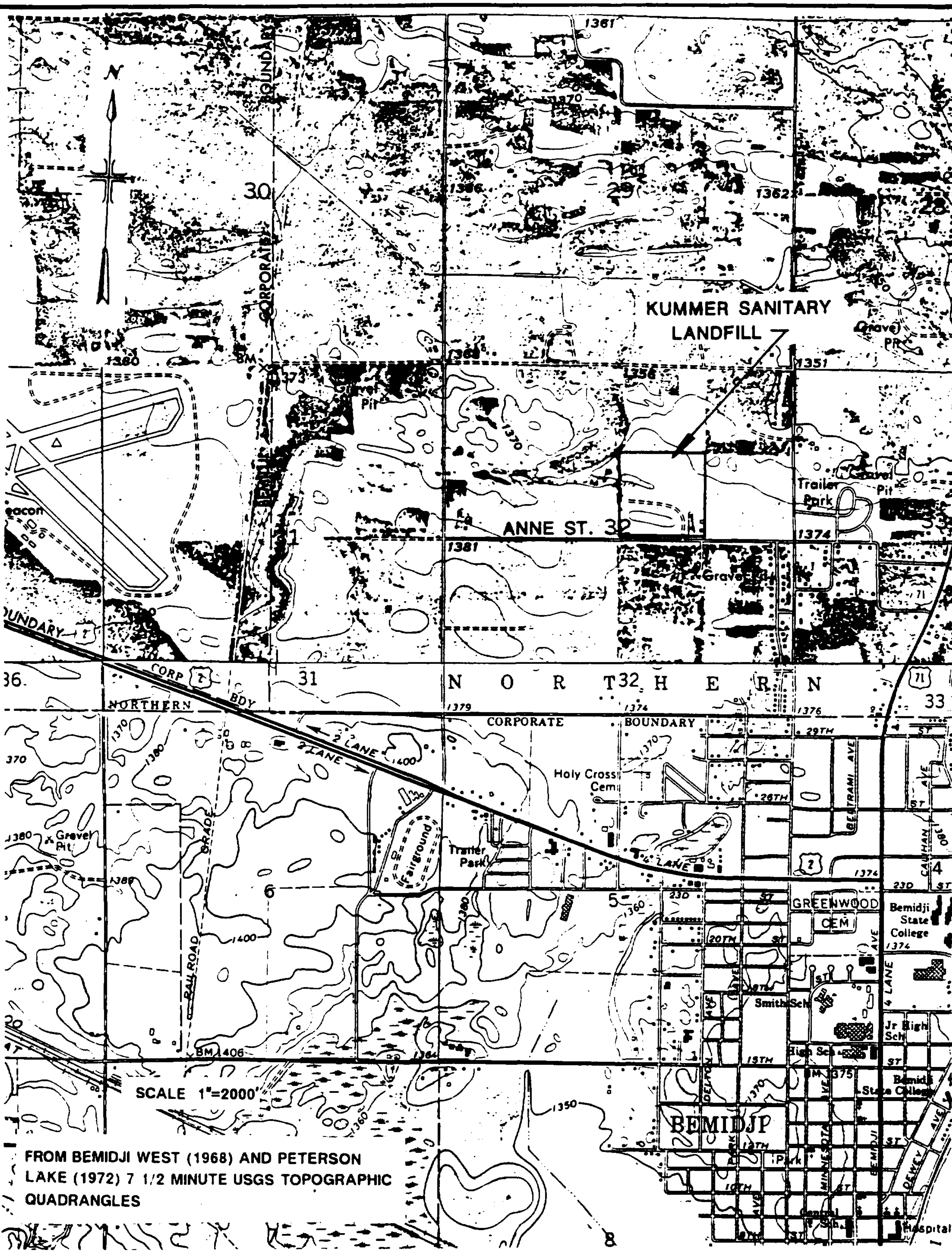
KUMMER LANDFILL

REMEDIAL INVESTIGATION

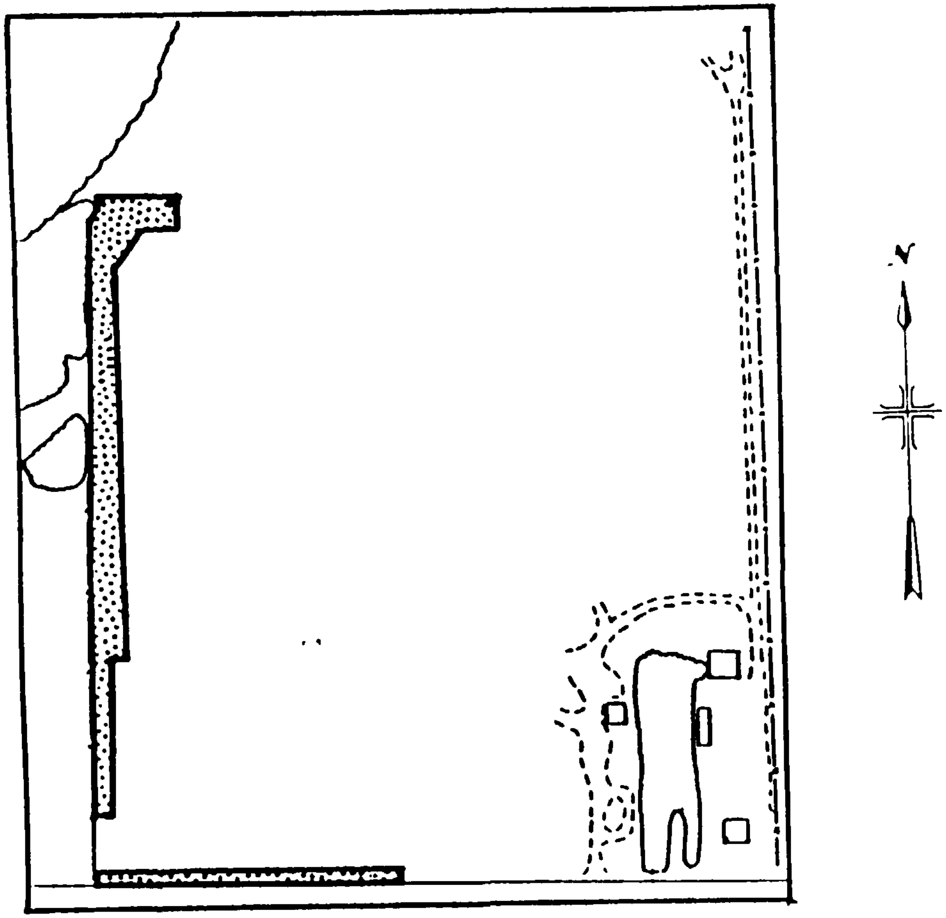
LOCATION OF NORTHERN TOWNSHIP

MALCOLM PIRNIE, INC.

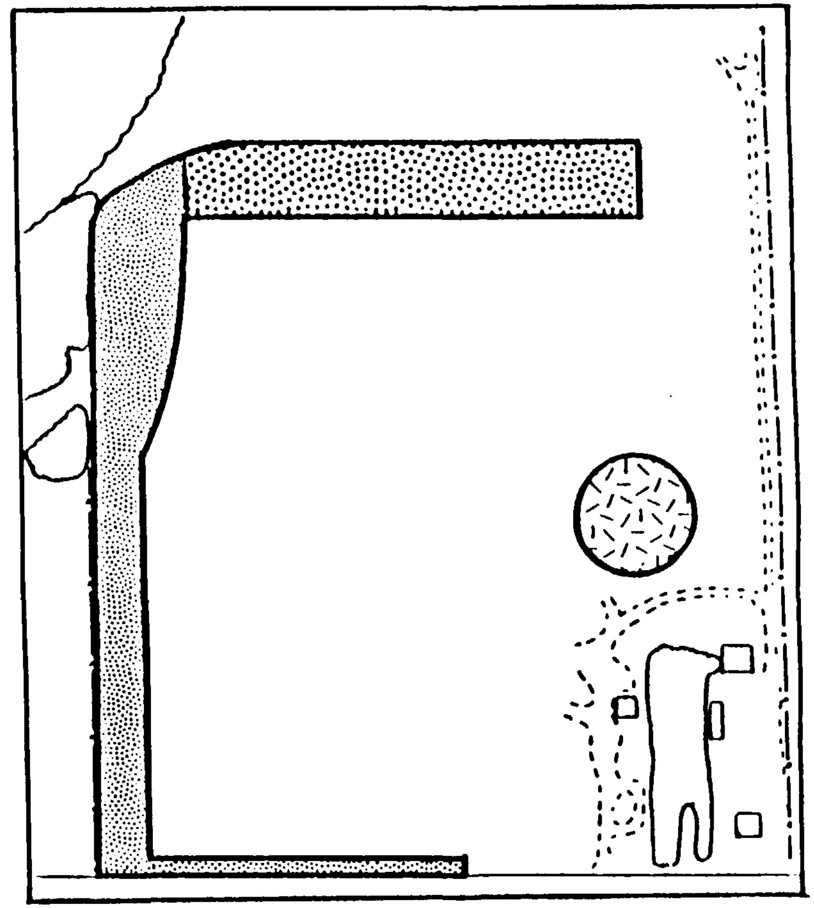
FIGURE 1-1



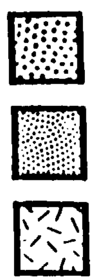
MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION SITE LOCATION	MALCOLM PIRNIE, INC.	FIGURE 1-2



KUMMER LANDFILL BEMIDJI, MINNESOTA
MAY 1972



KUMMER LANDFILL BEMIDJI, MINNESOTA
1974



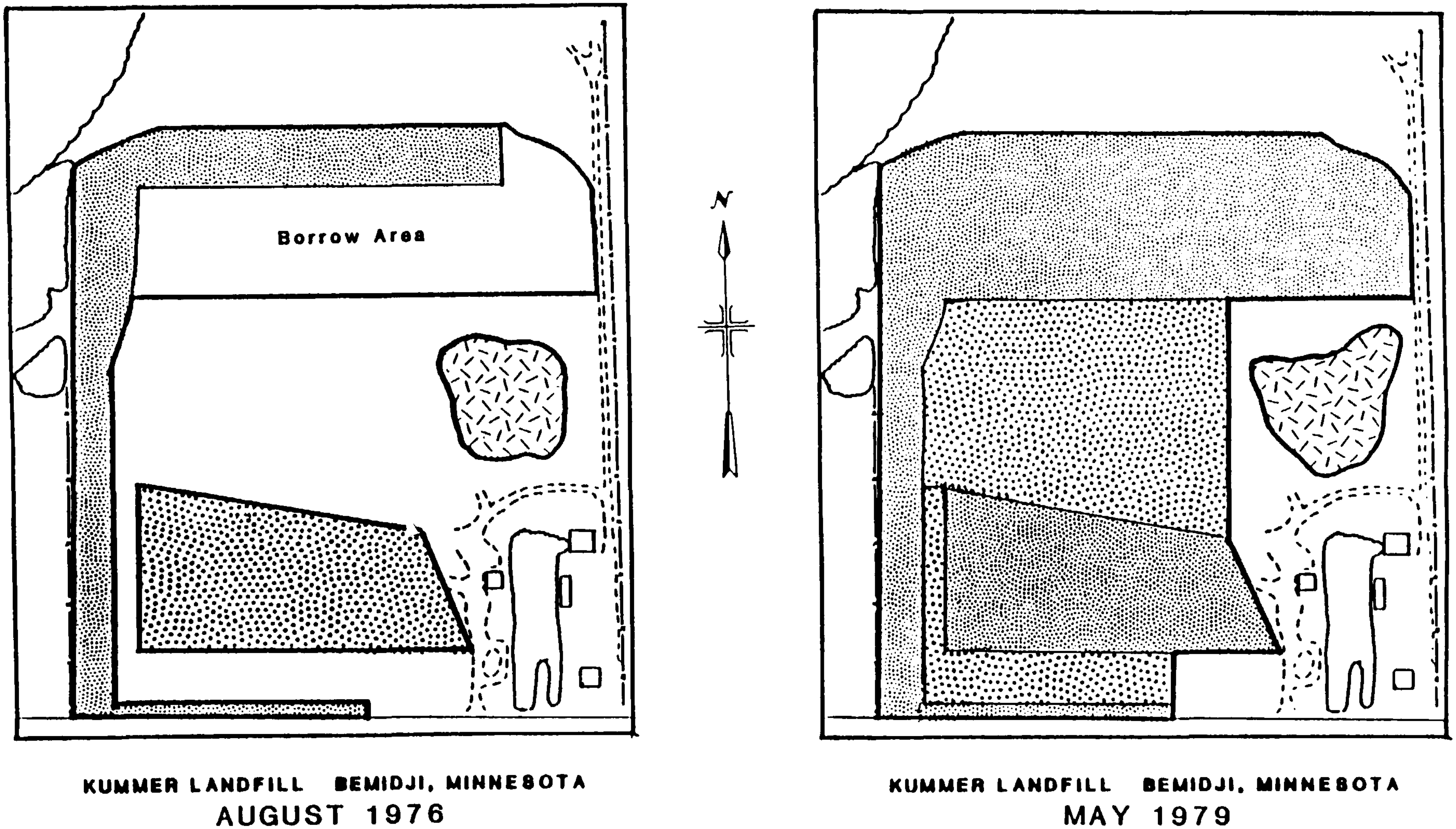
CURRENTLY ACTIVE FILL AREA

PREVIOUSLY FILLED AREA

DEMOLITION AREA

NOT TO SCALE

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION HISTORY OF SITE OPERATIONS	MALCOLM PIRNIE, INC. FIGURE 1-3



CURRENTLY ACTIVE FILL AREA

PREVIOUSLY FILLED AREA

DEMOLITION AREA

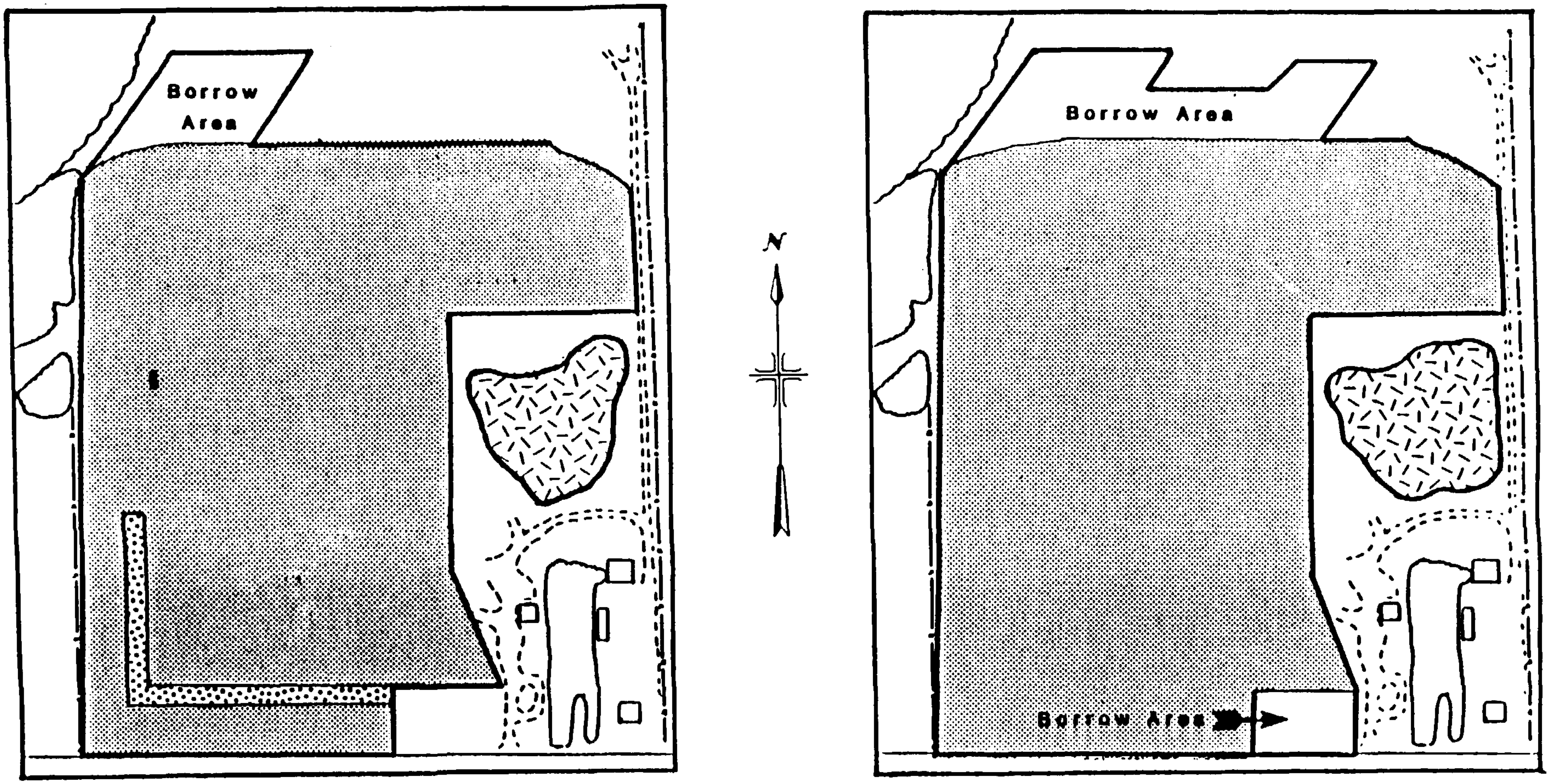
NOT TO SCALE

MALCOLM PIRNIE

KUMMER LANDFILL
REMEDIAL INVESTIGATION
HISTORY OF SITE OPERATIONS

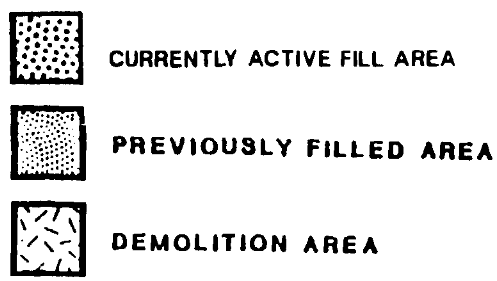
MALCOLM PIRNIE, INC.

FIGURE 1-4



KUMMER LANDFILL BEMIDJI, MINNESOTA
1981

KUMMER LANDFILL BEMIDJI, MINNESOTA
JULY 1983



NOT TO SCALE

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION HISTORY OF SITE OPERATIONS	MALCOLM PIRNIE, INC. FIGURE 1-5

of the site taken by MPCA personnel during regular site inspections were used to adequately differentiate between active and inactive portions of the landfill. In addition to providing important documentation concerning active trench locations, a number of violations of landfill operation are shown in the photographs. Most frequently noted violations included failure to provide adequate cover, failure to control litter and blowing debris, and improper grading of the cover material which caused surface water to drain into active trenches.

Additional information for the sketches originated from examination of MPCA Solid Waste Facility Site Inspection Reports and Site Operation Reports. Finally conversations with Mr. Larry Olson, Regional Inspector based in the MPCA's Detroit Lakes Office, helped to tie all the reports and photographs together.

Three monitoring wells were installed on the landfill property in the summer of 1971. These were identified as Well 1, also known as (AKA) the Kummer Well, or the house well; Well 2, renamed Well H by Mr. G.M. Sunde, a consultant to Mr. Kummer in 1980; and Well 3, also renamed Well F by Mr. Sunde. In 1980, Wells A through I were installed and subsequently Well J was added. All of the monitoring wells existing prior to this remedial investigation were installed by Mr. Kummer. Plate I shows the locations of the on-site monitoring wells except Well J, the location of which is unknown. No well logs or field notes were kept during installation of these monitoring wells. Elevations for the wells were not surveyed to mean sea level or an arbitrary datum. In addition, information in the files of MPCA (Jakes, 1982, Olson, 1972-1985) indicates that proper maintenance of the wells was not performed. This may have led to contamination of the ground water via open annular spaces or vandalism. MPCA files (Jakes, 1982) indicate apparent confusion over the labeling of the monitoring wells during many of the sampling surveys. There is only limited information on the depths and elevations of the monitoring wells.

From its opening in 1971 to November of 1984 the landfill accepted material described only as mixed-municipal waste. Examination of MPCA files reveal no further classification of the material beyond this description. The waste was deposited in the landfill using a trench-and-fill technique. Early trenches were located along the southern, western, and northern borders of the property. Cover material was excavated from borrow areas within the landfill. In some cases, these borrow areas later became active fill sites.

In 1974, a demolition debris disposal area was opened at the landfill. This area, located near the eastern edge of the site and shown on Figure 1-3, contains large quantities of fly ash and sawdust. The fly ash most likely originated from Bemidji State University. Based upon correspondence between Mr. Kummer and the university, it appears the fly ash originated from the campus incinerator. The sawdust probably originated at the Superwood Company also in Bemidji, and may represent the scrap material from the many pressed wood products manufactured there.

Because of the violations already noted, MPCA staff issued a Notice of Noncompliance dated March 6, 1979 and a Notice of Violation dated May 15, 1979 to Mr. Kummer for failure to comply with MPCA Rule SW-6. MPCA Rule SW-6 provides regulatory guidelines for the maintenance and operation of landfills in the State of Minnesota. The rule requires, among other things, that deposited wastes be covered daily with at least 6 inches of cover material, that wind blown debris be collected daily, that surface water drainage be diverted away from the operating area, and that the deposited material not cause pollution of underground water. Mr. Kummer failed to comply with the requirements for corrective action set out by the Notice of Noncompliance and the Notice of Violation. On December 18, 1979, Mr. Kummer entered into a Stipulation Agreement with the MPCA in order to bring the landfill into compliance with Minnesota rules and regulations. MPCA then found that conditions in the Stipulation Agreement were being violated and that there were continued violations of MPCA Rule SW-6.

On April 19, 1983, the State commenced legal action against Mr. Kummer for alleged violations of Minnesota statutes, MPCA solid waste and water quality rules, the Minnesota Environmental Rights Act, and the December 18, 1979 Stipulation Agreement. On

May 4, 1982, July 7, 1983 and October 4, 1983, the MPCA staff sampled ground water from the landfill's monitoring wells. Nineteen volatile organic compounds (VOC's) were found present in the downgradient wells while the upgradient wells were uncontaminated, indicating ground water contamination as a result of the landfill operation. These VOC's included trichlorofluoromethane, 1,1,2,2-tetrachloroethylene, benzene, 1,2-dichloroethane, and 1,1,2-trichloroethylene. On May 23, June 11 and July 5, 1984, MPCA staff sampled shallow private potable wells downgradient of the landfill which revealed the presence of numerous volatile organic compounds, fourteen of which were identified in the Kummer Sanitary Landfill monitoring wells. Measurements indicated that some volatile organic compounds were present in the ground water at concentrations which exceed levels recommended to protect human health. Although preliminary data indicated that shallow ground water flowed from the landfill toward the residences whose wells are affected, it was thought that further study was necessary to verify that the Kummer Sanitary Landfill was the source of the potable well contamination.

On June 26, 1984, MPCA issued a Request for Response Action to Mr. Kummer, under the Minnesota Environmental Response and Liability Act, Minn. Stat. Ch. 115B, requesting him to undertake a remedial investigation/feasibility study at and around the landfill, appropriate remedial action, the development and implementation of a long-term ground water monitoring plan, and the development of a closure plan. However, on August 1, 1984, Mr. Kummer informed MPCA staff that he was unable to conduct the activities requested in the Request for Response Action and that he would voluntarily close the landfill. The MPCA subsequently issued a Determination of Inadequate Response to the Permittee on August 28, 1984 for his failure to conduct the activities requested in the Request for Response Action. By October 1, 1984, no waste except for demolition material was being accepted at the landfill. The demolition debris was to be used for filling holes and depressions in order to facilitate closure activities at the landfill. The MPCA staff inspected the landfill on November 16, 1983, January 27, 1984, February 15, 1984, March 23, 1984, April 30, 1984, June 20, 1984, October 8, 1984 and November 8, 1984. These inspections identified continuing violations of the Stipulation Agreement and MPCA solid waste rules.

On April 1, 1985, personnel from MPCA's Detroit Lakes regional office observed that the Permittee had reopened the landfill and was willing to accept mixed municipal solid waste. The Beltrami County attorney then obtained a temporary restraining order on April 4, 1985 which was served on Mr. Kummer to prevent the disposal of solid waste at the landfill. The MPCA then issued an Administrative Order on June 25, 1985 closing the landfill, revoking permit SW-31 and requiring Mr. Kummer to begin ground water monitoring at the site.

On September 29, 1984, the United States Environmental Protection Agency (EPA) and the MPCA executed a Cooperative Agreement which provided funding for implementing a Remedial Investigation and Feasibility Study (RI/FS) for the Kummer Sanitary Landfill. In October, 1984, the site was proposed for inclusion onto the National Priorities List. In May 1986, the site's inclusion on the list was finalized by the EPA. On August 8, 1985, Malcolm Pirnie was issued a site assignment to prepare a Remedial Investigation/Feasibility Study Work Plan for the site.

Concurrently, the MPCA conducted a focused Feasibility Study to address the problem of providing potable water to affected residents. This study concluded that a community water supply and distribution system should be constructed in the area. USEPA awarded funding to MPCA to construct such a system. Construction is proceeding at this time.

1.4 GROUND WATER MONITORING HISTORY

MPCA files contain over 200 analytical reports of samples from ten landfill monitoring wells and 64 residential and commercial wells. Of the 10 landfill monitoring wells, Well 1, a downgradient well located at the Kummer house at 901 Anne Street, had been sampled at least twice every year from 1971 to 1982 except in 1981 when it was sampled once. Well 2 (AKA Well H), an upgradient well, was also sampled whenever the Kummer house well was sampled. Well 3 (AKA Well F), considered a downgradient well, was sampled intermittently during this same period. The remaining monitoring wells A, B, C, E, G, and I, were installed in 1980, and were sampled several times in 1982 and 1983. Well D which may have been a utility well in the shop building located west of the Kummer residence was apparently never sampled.

All of the monitoring wells and at least 64 residential or commercial wells were sampled at least once for 54 volatile organic parameters. From 1971 to 1978, the three original monitoring wells, Well 1 (Kummer House Well), Well 2 (Well H), and Well 3 (Well F) were sampled by Mr. Charles Kummer. Those samples were analyzed by SERCO Laboratories (1971 to 1973) and Minnesota Valley Testing Laboratories (approximately 1974 to 1978). From 1978 through 1983, the samples were collected and analyzed by either Bemidji State University (1979 to 1982) or the Minnesota Department of Health, MDH, (1978-1979, 1982-1985). A number of inorganic and organic analyses were performed on samples from residential and commercial wells in the vicinity of the landfill from 1982 through 1985. These samples were collected by representatives of the MPCA and were analyzed by the MDH.

Although considerable water quality data is available from the landfill monitoring wells prior to the start of this remedial investigation, the lack of sampling consistency and quality control for the sampling surveys conducted before 1978 (after which time sample collection was performed by laboratory and MPCA personnel) severely limit the reliability of the early water quality data. Even after better quality control measures were instituted in 1978, the poor condition and lack of maintenance of the monitoring wells leaves considerable doubt about subsequent data collected by the MPCA and analyzed by the MDH laboratories.

1.5 PAST GROUND WATER QUALITY DATA

Information given in this section is analytical data generated by MPCA and MDH prior to commencement of the remedial investigation. This data includes water quality parameters and metals (collectively called inorganic data) and organic analyses.

1.5.1 Inorganic Water Quality Data

Inorganic water quality data are presented in Table 1-1. The only water quality data from a shallow water-bearing formation before construction of the landfill are from the three original ground water monitoring wells installed at the landfill. Data for only three parameters - chloride, pH and nitrate-nitrite as nitrogen (hereinafter referred to as nitrate), were obtained from these early analyses. Chloride concentrations ranged from 2 to 3 milligrams/liter. The values for pH ranged from 6.8 to 7.2. Nitrate concentration was 0 mg/l (detection level unknown) in all three wells. Appendix A contains inorganic water quality data prepared by MPCA as included in the table attached to Mr. Jake's memo of 1982.

1.5.2 Organic Water Quality Data

Selected organic water quality data are presented in Table 1-2. The data were selected so as to generally illustrate ground water quality conditions in the area. Upgradient data available for monitoring Well H, and the maintenance well at the North Country Hospital is tabulated in Table 1-2. None of the organic parameters tested in samples of ground water from Wells H or I were found above or near the detection levels of the laboratory method utilized by the MDH laboratory. The sample from the hospital maintenance well contained bromodichloromethane (0.7 ug/l) and chloroform (2.4 ug/l).

Twenty-five halogenated and nonhalogenated compounds (including those discussed in the previous paragraph) were detected in downgradient monitoring wells and private wells. These parameters are listed in Table 1-3. Concentrations for these parameters in the downgradient monitoring wells ranged from barely detectable levels to 130 ug/l (tetrahydrofuran). The highest concentration for an organic compound found in a private well was 46 ug/l (methylene chloride). Most of the organic compounds were found at concentrations less than 10 ug/l.

A list of the private wells (residential and commercial) sampled prior to the start of this remedial investigation and the date(s) sampled is included as Appendix B. Based on data collected through 1984, most of the contaminated private wells were

TABLE 1-1

PRE-RI INORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION

Well Identification	[redacted]				
Sample Collection Date	11/6/80	11/1/81	11/1/82	1/4/83	1/12/82
pH	6.8	7.8	7.7	7.8	7.1
Specific Conductivity	350.	350.	380.	370.	380.
M-O Alkalinity					200.
Alkalinity, Total		200.	200.	210.	
Hardness, Total	200.	198.	195.	189.	190.
Residue , Total	410.	230.0	220.	220.	
Residue, Total FLT (Diss.)					180.
Sulfate	5.0	5.00	5.0	5.00	5.0
COD	25.	5.0	6.3	5.0	6.0
Carbon, TOC	2.30	4.70	2.10	1.90	1.0
Nitrogen, TKN	0.25	0.430	0.30	0.500	0.42
Nitrogen, Ammonia	0.21	0.22	0.24	0.22	0.16
Nitrate					0.01
Organic Nitrogen	1.00	0.21	0.10	0.28	
Nitrate + Nitrite	0.40	0.40	0.40	0.400	
Phosphorus, Total	0.06	0.074	0.151	0.107	0.050
Chloride		0.50	0.50	0.50	0.5
Fluoride	0.12				
Calcium, Total	140.	140.	135.	130.	130.
Magnesium, Total	60.	58.	60.	59.	55.
Potassium, Total	1.3	1.20	1.47	1.34	1.5
Sodium, Total	2.82	2.79	2.61	2.75	2.6
Aluminum, Total					0.008
Arsenic, Total	0.005	0.005	0.0056	0.005	
Cadmium, Total	0.001	0.001	0.001	0.001	
Chromium, Total	0.005	0.005	0.005	0.005	
Copper, Total	0.050	0.050	0.050	0.095	
Iron, Total	0.64	0.860	1.80	0.600	0.340
Lead, Total	0.010	0.010	0.010	0.010	
Manganese, Total	0.23	0.230	0.210	0.220	0.230
Nickel, Total	0.050	0.050	0.050	0.050	
Zinc, Total	0.077	0.010	0.012	0.027	

*Mobile Home Court
Concentration units are mg/l

TABLE 1-1

PRE-RI INORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Well Identification	NON-RESPONSIVE [redacted]			
Sample Collection Date	5/24/84	5/24/84	5/24/84	5/24/84
pH	7.4	7.6	7.6	7.8
Specific Conductivity				
M-O Alkalinity	260.	260.	230.	240.
Alkalinity, Total				
Hardness, Total	280.	260.	280.	260.
Residue , Total Suspended Solids	0.56	0.5	0.5	0.5
Residue, Total FLT (Diss.)	310.	320.	370.	330.
Sulfate	19.	12.	17.	10.
COD	5.	5.	5.	5.
Carbon, TOC				
Nitrogen, TKN				
Nitrogen, Ammonia	0.02	0.02	0.02	0.02
Organic Nitrogen				
Nitrate + Nitrite	9.1	2.7	13.	1.3
Phosphorus, Total				
Chloride	210.	6.3	14.	25.
Fluoride				
Calcium, Total	210.	190.	210.	180.
Magnesium, Total	70.	74.	74.	77.
Potassium, Total	3.5	0.8	1.3	0.7
Sodium, Total	150.	3.5	12.	4.1
Arsenic, Total	0.0050	0.0010	0.0020	0.0010
Cadmium, Total	0.023	0.013	0.018	0.057
Chromium, Total	0.0005	0.0005	0.0005	0.0005
Copper, Total	0.0091	0.011	0.016	0.0085
Iron, Total	0.020	0.020	0.020	0.020
Lead, Total	0.0005	0.0004	0.0003	0.0012
Manganese, Total	0.005	0.003	0.003	0.003
Mercury, Total	0.00010	0.00010	0.00010	0.00010
Nickel, Total				
Zinc, Total	0.0097	0.036	0.013	0.130

Concentration units are mg/l

TABLE 1-1

PRE-RI INORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Well Identification	Well H	Well H	Well H	Well H	Well I	Well I
Sample Collection Date	6/20/78	8/10/78	1/11/82	5/4/82	1/11/82	5/4/82
ph	7.3	7.6	7.2	7.08	7.2	6.8
Specific Conductivity	340.	380.	320.	330.	440.	380.
Turbidity			1.0		1.3	
M-O Alkalinity			180.		240.	
Bicarb Alkalinity			180.		240.	
Alkalinity, Total						
Hardness, Total	170.	201.	170.	160.	280.	220.
Residue , Total	180.					
Suspended Solids	0.8			1.2	76.	
Residue, Total FLT (Diss.)	180.		210.	190.	140.	210.
Sulfate	5.0		6.3		5.0	
COD	5.	6.	20.		11.	
Carbon, TOC	1.8	1.7	6.1		1.2	
Nitrogen, TKN			0.18	0.10	0.21	0.30
Nitrogen, Ammonia		0.09	0.02	0.02	0.02	0.02
Organic Nitrogen						
Nitrate + Nitrite	0.46	0.44				
Nitrite	0.01		0.01		0.01	
Phosphorus, Total	0.026		0.080	0.032	0.170	0.152
Chloride	0.50	0.61	0.50	0.50	0.5	0.77
Fluoride						
Calcium, Total	120.		120.	110.	200.	160.
Magnesium, Total	50.		48.	47.	78.	60.
Potassium, Total	0.57		0.5		0.7	
Sodium, Total	1.8		1.5		1.6	
Aluminum, Total					0.460	
Arsenic, Total	0.0012					
Cadmium, Total	0.010	0.010		0.010		0.010
Chromium, Total	0.00077					
Copper, Total	0.050	0.050				
Iron, Total	0.200		0.480	0.190	5.500	4.50
Lead, Total	0.050			0.050		0.050
Manganese, Total	0.020		0.020	0.020	0.350	0.190
Nickel, Total	0.050	0.050				
Zinc, Total	0.140	0.160		0.150		1.900

TABLE 1-2

PRE-RI ORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION

VOLATILES

RESIDENT WELL OWNER:	Field Blank	[redacted]								
DATE SAMPLED:	1/10/85	[redacted]								
DATE ANALYZED:	1/15	5/6	5/6	7/30	5/7	5/7	4/23	5/8	5/8	1/15
Non-Halogenated Compounds										
Acetone										
Ethyl Ether										P(
Benzene										
Toluene										
Cumene										
M-Xylene										
Tetrahydrofuran										
Methyl Ethyl Ketone										
Methyl Isobutyl Ketone										
Ethylbenzene										
O-Xylene										
P-Xylene										
Halogenated Compounds										
Chloromethane		NA	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl Chloride		NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroethane		NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	1.10					1.1				
Allyl chloride										
1,1-Dichloroethane						P(				
Cis-1,2-Dichloroethylene			1.30	1.60						
1,2-Dichloroethane							0.40	0.20		
1,1,1-Trichloroethane							0.30			
Bromodichloromethane										
2,3-Dichloro-1-Propene										
1,1-Dichloro-1-Propene										
1,1,2-Trichloroethylene										
Chlorodibromomethane										
Cis-1,3-Dichloro-1-Propene										
2-Chloroethylvinyl Ether		NA	NA		NA	NA		NA	NA	
1,1,1,2-Tetrachloroethane										
1,1,2,2-Tetrachloroethane										

NOTES:
(........ Less than
P(....... Peak detected below the "less than" value
PP .... A peak was present
NA .... Not analyzed
units are ug/l

(continued)

TABLE 1-2

PRE-RI ORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

VOLATILES

RESIDENT WELL OWNER:	[redacted]									
DATE SAMPLED:	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	7/25/84	7/25/84
DATE ANALYZED:	1/15	1/15	1/15	1/15	1/15	1/15	1/15	1/15	7/30	7/30
Non-Halogenated Compounds										
Acetone									40.00	16.00
Ethyl Ether		P(			0.10		0.10			
Benzene										
Toluene										
Cumene										
M-Xylene										
Tetrahydrofuran										
Methyl Ethyl Ketone										
Methyl Isobutyl Ketone										
Ethylbenzene										
O-Xylene										
P-Xylene										
Halogenated Compounds										
Chloromethane	NA	NA	NA	NA	PP	NA	NA	NA	NA	NA
Vinyl Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride					1.90		5.90			
Allyl chloride										
1,1-Dichloroethane					0.70		0.70		0.30	0.40
Cis-1,2-Dichloroethylene		0.70			0.40					
1,2-Dichloroethane					P(					
1,1,1-Trichloroethane					0.40				0.20	0.50
Bromodichloromethane										
2,3-Dichloro-1-Propene										
1,1-Dichloro-1-Propene										
1,1,2-Trichloroethylene										
Chlorodibromoethane										
Cis-1,3-Dichloro-1-Propene										
2-Chloroethylvinyl Ether										
1,1,1,2-Tetrachloroethane										
1,1,2,2-Tetrachloroethane										

NOTES:
(........ Less than
P(....... Peak detected below t
PP .... A peak was present
NA .... Not analyzed
units are ug/l

(continued)

TABLE 1-2

PRE-RI ORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

VOLATILES

RESIDENT WELL OWNER:	[redacted]						
DATE SAMPLED:	10/9/84	5/4/82	7/25/84	5/23/84	5/23/84	5/23/84	5/23/84
DATE ANALYZED:	10/11	5/5	7/30	6/6	6/6	6/6	6/6
Halogenated Compounds (continued)							
Pentachloroethane		<					
1,1,2-Trichlorotrifluoroethane		<					
1,2-Dichlorobenzene		<					
Dichlorodifluoromethane		<	NA	NA	PP	NA	PP
Bromomethane		-	NA	NA	NA	NA	NA
Dichlorofluoromethane		<	NA	NA	PP	NA	PP
Trichlorofluoromethane		<		P<	0.30		1.20
1,1-Dichloroethene		<					0.20
Trans-1,2-Dichloroethylene		<					
Chloroform		<	2.40	P<			0.70
Dibromomethane		<					
Carbon Tetrachloride							
Dichloroacetonitrile		<					
1,2-Dichloropropane		<					0.20
Trans-1,3-Dichloro-1-Propene		<					
1,3-Dichloropropane		-					
1,1,2-Trichloroethane		<					1.70
1,2-Dibromoethane		-					0.40
Bromoform		<					
1,2,3-Trichloropropane							
1,1,2,2-Tetrachloroethylene							3.00
Chlorobenzene							
1,3-Dichlorobenzene							
1,4-Dichlorobenzene							

(continued)

NOTES:
< .... Less than
P< .... Peak detected below the "less than" value
PP .... A peak was present
NA .... Not analyzed
units are ug/l

TABLE 1-2

PRE-RI ORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

VOLATILES

RESIDENT WELL OWNER:	[redacted]						
DATE SAMPLED:	10/9/84	5/4/82	7/25/84	5/23/84	5/23/84	5/23/84	5/23/84
DATE ANALYZED:	10/11	5/5	7/30	6/6	6/6	6/6	6/6
Non-Halogenated Compounds							
Acetone		<					
Ethyl Ether	1.20	<			P<		3.00
Benzene		<					
Toluene		<					
Cumene		<					
M-Xylene		<					
Tetrahydrofuran		<					12.00
Methyl Ethyl Ketone		<					
Methyl Isobutyl Ketone		<					
Ethylbenzene		<					
O-Xylene		<					
P-Xylene		<					
Halogenated Compounds							
Chloromethane		<	NA	NA	PP	NA	PP
Vinyl Chloride		<	NA	NA	NA	NA	NA
Chloroethane		<	NA	NA	NA	NA	PP
Methylene chloride	1.30	<					9.80
Allyl chloride		<					
1,1-Dichloroethane		<			0.20		1.90
Cis-1,2-Dichloroethylene		<					6.60
1,2-Dichloroethane		<		0.80	0.90		0.70
1,1,1-Trichloroethane		<					0.90
Bromodichloromethane		<	0.70				
2,3-Dichloro-1-Propene		<					
1,1-Dichloro-1-Propene							
1,1,2-Trichloroethylene							
Chlorodibromoethane			P<				
Cis-1,3-Dichloro-1-Propene							
2-Chloroethylvinyl Ether		-					
1,1,1,2-Tetrachloroethane		<					
1,1,2,2-Tetrachloroethane		<					

NOTES:
< .... Less than
P< .... Peak detected below t
PP .... A peak was present
NA .... Not analyzed
units are ug/l

(continued)

TABLE 1-2

PRE-RI ORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

VOLATILES

RESIDENT WELL OWNER:	[redacted]									
DATE SAMPLED:	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	1/10/85	7/25/84	7/25/84
DATE ANALYZED:	1/15	1/15	1/15	1/15	1/15	1/15	1/15	1/15	7/30	7/30
Halogenated Compounds (continued)										
Pentachloroethane										
1,1,2-Trichlorotrifluoroethane										
1,2-Dichlorobenzene										
Dichlorodifluoromethane	NA	NA		NA	PP	NA	NA	NA	PP	PP
Bromomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dichlorofluoromethane	NA	NA	NA	NA	NA	NA	NA	NA	PP	PP
Trichlorofluoromethane					0.20	0.20			0.20	0.50
1,1-Dichloroethene										
Trans-1,2-Dichloroethylene										
Chloroform									(P	
Dibromomethane										
Carbon Tetrachloride										
Dichloroacetonitrile										
1,2-Dichloropropane										
Trans-1,3-Dichloro-1-Propene										
1,3-Dichloropropane										
1,1,2-Trichloroethane										
1,2-Dibromoethane										
Bromoform										
1,2,3-Trichloropropane										
1,1,2,2-Tetrachloroethylene										
Chlorobenzene										
1,3-Dichlorobenzene										
1,4-Dichlorobenzene										

NOTES:
(........ Less than
P(....... Peak detected below the "less than" value
PP .... A peak was present
NA .... Not analyzed
units are ug/l

(continued)

TABLE 1-2

PRE-RI ORGANIC WATER QUALITY DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

VOLATILES

RESIDENT WELL OWNER:	Field Blank	NON-RESPONSIVE [redacted]								
DATE SAMPLED:	1/10/85	4/23/85	4/23/85	7/25/84	4/23/85	4/23/85	10/9/84	10/12/84	4/23/84	1/10/85
DATE ANALYZED:	1/15	5/6	5/6	7/30	5/7	5/7	4/23	5/8	5/8	1/15
Halogenated Compounds (continued)										
Pentachloroethane										
1,1,2-Trichlorotrifluoroethane										
1,2-Dichlorobenzene										
Dichlorodifluoromethane		NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromomethane		NA	NA	NA	NA	NA	NA	NA	NA	NA
Dichlorofluoromethane		NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichlorofluoromethane										
1,1-Dichloroethene								P(		
Trans-1,2-Dichloroethylene										
Chloroform										
Dibromomethane										
Carbon Tetrachloride										
Dichloroacetonitrile		NA	NA	NA	NA	NA	NA	NA		
1,2-Dichloropropane										
Trans-1,3-Dichloro-1-Propene										
1,3-Dichloropropane		NA	NA	NA	NA	NA	NA	NA		
1,1,2-Trichloroethane										
1,2-Dibromoethane										
Bromoform										
1,2,3-Trichloropropane		NA	NA	NA	NA	NA	NA	NA		
1,1,2,2-Tetrachloroethylene										
Chlorobenzene										
1,3-Dichlorobenzene										
1,4-Dichlorobenzene										

NOTES:
(........ Less than
P(....... Peak detected below the 'less than' value
PP .... A peak was present
NA .... Not analyzed
Units are ug/l

(continued)

TABLE 1-3

RANGE OF LEVELS OF VOLATILES DETECTED IN GROUND WATER
KUMMER LANDFILL REMEDIAL INVESTIGATION

	Lowest	Highest
Methylene Chloride	1.0	46.0
1,1-Dichloroethane	0.3	5.4
cis 1-2-Dichloroethylene	0.2	27.0
1,1,2-Trichloroethylene	0.2	2.7
Trichlorofluoromethane	0.2	5.6
1,1-Dichloroethylene	0.2	1.7
1-2,Dichloropropane	0.2	1.7
Vinyl Chloride		
Chloromethane		
Dichlorofluoromethane		
Bromomethane		
1,2-Dichloroethane	0.1	4.2
1,1,1-Trichloroethane	0.2	8.8
Dichlorodifluoromethane		
Acetone	16.0	100.0
Ethyl Ether	0.1	60.0
Benzene	0.3	3.1
Toluene	0.5	6.8
Total Xylenes	0.6	8.2
Tetrahydrofuran	0.5	130.0
Ethyl Benzene	0.5	8.0
1,1,2,2-Tetrachloroethylene	2.0	16.0
Chloroform	0.2	2.4
Chloroethane		
1,1,2,2-Tetrachlorethane	2.0	4.6
1,2-Dibromomethane	0.4	0.7
Bromodichloromethane	0.2	0.7
1,2-Dibromoethane	0.4	0.7
Trichloroethene	0.2	2.8
Methyl Isobutyl Ketone	5.0	6.0
1,1-Dichloro-1-Propane	0.2	1.8

All values in micrograms/liter.

If no Lowest-Highest value is given, the volatile organic compound was detected as a peak below the detection level.

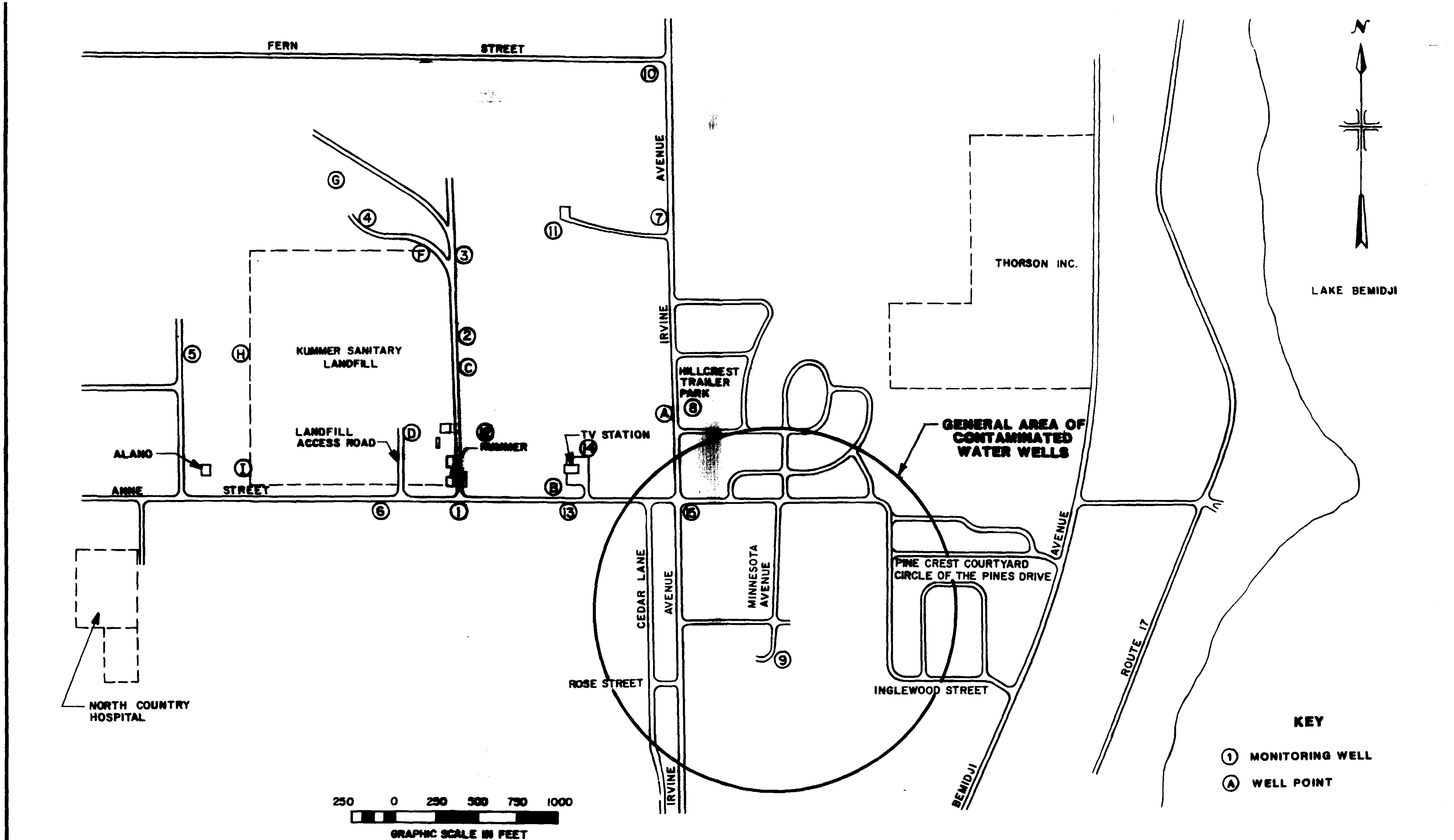
located in a six square block area east of the landfill, south of Anne Street (38th Street), north of Lilac Street, and west of Bemidji Avenue North. This area is shown on Figure 1-6. Four other contaminated wells were located east of Bemidji Avenue North, one was located north of Anne Street and one south of Robertson Drive. A review of 1985 data collected in January and April revealed that the W. Elliot well located within the above mentioned three block area, which had originally show contamination, had improved. However, the M. F. Field well also located within the three block area, that was originally clean was then found to contain organic compounds. Also, the D. Miller well located east of Bemidji Avenue, which had been clean in 1984 was then found to be contaminated in later sampling. One other previously sampled well (W. Cameron) located south of Robertson Drive was found to be contaminated.

No new organic contaminants from those found in 1984 were found in 1985 sampling surveys. The concentrations of some parameters increased while others either decreased or were no longer found. Overall, concentrations were slightly lower.

Those wells which had shown quantifiable concentrations of organic contamination were grouped by depth. Both the Channel 26 television station well which is is 117 feet deep, and the Hillcrest Manor Mobile Home Park well, which is assumed to be over 100 feet deep, did not show detectable levels of organic contaminants. Only four out of 10 wells in the depth range of 40 to 90 feet had detectable levels of contaminants. Six out of eight wells were contaminated in the 30 to 40-foot range, six out of 13 in the 20 to 30-foot range and two out of four in the 10 to 20-foot range. The above statistics do not include approximately 15 wells which were described as either shallow or deep or for which there was no information on depth.

1.6 SCOPE OF WORK

On August 8, 1985, MPCA issued a Site Assignment to Malcolm Pirnie authorizing preparation of a RI/FS Work Plan Scope of Work for the Kummer Sanitary Landfill site. This is the first element in a series of tasks designed by MPCA to investigate a site,



Base map from orthophoto flown in 1985.
Wells surveyed in 1986, 1988.

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION MINNESOTA POLLUTION CONTROL AGENCY	GENERAL AREA OF CONTAMINATED WATER WELLS BASED ON PRE-1986 DATA	MALCOLM PIRNIE, INC. FIGURE 1-6

determine feasible remedial alternatives, and identify the most appropriate corrective action.

The first task entailed a preliminary review of files made available by MPCA staff. This review was conducted on August 6 and 14 by Malcolm Pirnie project personnel. Photocopies of important documents were requested and received. Such information included site sketches, analytical data, inspection reports, and agency correspondence.

The second task of the Scope of Work included a field reconnaissance of the site in Northern Township. This site visit was conducted on August 16, 1985 by MPCA and Malcolm Pirnie personnel. Observations of site conditions were noted in the Scope of Work Plan.

The third task of the Scope of Work included a written description of how the major components of the RI/FS Work Plan were to be prepared. A budget, or Payment Schedule estimating costs for preparing the Work Plan was developed along with a Time Schedule for its implementation and completion.

A revised RI/FS Work Plan Scope of Work was submitted to MPCA on September 18, 1985. A supplemental RI Work Plan Scope of Work was submitted to MPCA on July 22, 1987, and a revised version on October 1, 1987. This supplemental work is described in Section 1.8.4.

1.7 RI/FS WORK PLAN

The RI/FS Work Plan Scope of Work was approved by MPCA by issuance of a Work Order on October 25, 1985 to Malcolm Pirnie to prepare the Kummer Sanitary Landfill RI/FS Work Plan. The Work Plan which was submitted to MPCA in April, 1986 contained the following components:

1. Chapter 1 - Evaluation Report
2. Chapter 2 - Quality Assurance Project Plan
3. Chapter 3 - Health and Safety Plan
4. Chapter 4 - Site Security Plan
5. Chapter 5 - Potential Responsible Party Search

6. Chapter 6 - RI/FS Work Plan

7. RI/FS Work Plan Time Schedule

8. RI/FS Payment Schedule

The Evaluation Report presented a detailed description of regional and local physiography, geology, and hydrology/hydrogeology. The site's location, history of operation, and area boundary features were detailed. Past sampling activity as well as past analytical results were reviewed and evaluated. The Evaluation Report also presented a problem assessment and described risks posed to human health and the environment posed by site conditions. Alternative response actions were identified for remediating site problems.

The Quality Assurance Project Plan (QAPP) presented in specific terms the policies, objectives, organization, functional activities and specific quality assurance and quality control activities designed to achieve the data quality goals for the Kummer remedial investigation. The QAPP detailed the guidelines and specifications describing sixteen essential elements of a quality assurance project plan. The format of the QAPP followed USEPA Document QAMS-005/8, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans." The QAPP for the Kummer remedial investigation was approved by MPCA on November 3, 1986 and by USEPA on November 26, 1986.

The Site Health and Safety Plan required that all project personnel involved with site investigations including borings, well installation, sampling, etc. perform project work in accordance with procedures outlined or referenced in the Plan. The following guidelines were referenced in order to protect the health and safety of on-site personnel and limit exposure of the public to potentially hazardous conditions, substances, or contaminants:

A. Section III (c) of CERCLA

B. OSHA Requirements (29 CFR 1910 and 1926)

C. Standard Operating Safety Guide, (Revised November, 1984) by the U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Hazardous Response Support Division.

The Site Security Plan was prepared to limit access to project work areas during the conduct of RI activities. Following an assessment of security needs, specific measures were developed to adequately address those needs.

The Potential Responsible Party Search was conducted during November 1985 and was performed in accordance with the guidelines expressed in the Kummer RI/FS Work Plan Scope of Work. The objective of the Kummer Sanitary Landfill Potential Responsible Party Search was to provide MPCA with data to aid in the development of legal and enforcement actions against responsible parties.

The methodology for the Potential Responsible Party Search followed the guidelines expressed in the USEPA document, "Procedures for Identifying Responsible Parties at Uncontrolled Hazardous Waste Sites," Office of Legal and Enforcement Counsel, Denver, Colorado, February 1982. The Potential Responsible Party Search for Kummer Sanitary Landfill was organized into six tasks. Each task incorporated the essential components described in the RI/FS Work Plan Scope of Work.

Chapter 6, RI/FS Work Plan presented in detail the investigation procedures which were proposed to be employed during the Remedial Investigation. The investigations outlined in the Work Plan were designed to: 1) generate data where existing data were lacking for the purpose of preparing the Remedial Investigation Final Report; 2) determine whether hazardous materials are migrating from the landfill site, 3) assess actual and potential impact on public health, welfare, and the environment; and 4) produce additional data of sufficient quantity and adequate technical content to identify and evaluate feasible alternative response actions.

The Work Plan was prepared based on a review of information and technical data available for the Kummer site as discussed in the Evaluation Report and upon the need for additional data to meet the requirements described above. A fundamental consideration in the development of the Work Plan was the need for information which would support the recommendation of a feasible and cost-effective alternative.

The Work Plan was a logical, sequenced approach which first addressed the questions of whether contaminants are migrating from the Kummer Landfill, what those contaminants and their concentrations are, how they are migrating from the site, and what hazards and risks are posed to public health and the environment by their release.

The Work Plan for the Kummer remedial investigation included the following activities:

1. Preliminary Field Inspections - Previously existing monitoring wells were to be inventoried, inspected, and tested in order to determine their suitability for water level measurements. Locations of new monitoring well locations were to be field verified.
2. Vadose Zone Monitoring - This field investigative activity was to involve sampling and qualitative analysis of soil gas present in the pore space of the unsaturated soil zone. The presence of volatile organic compounds, if any, measured in the pore space would be used in optimizing the placement of the new monitoring wells.
3. Ground water Monitoring Well Installation - The Work Plan proposed the installation of nine borings and 23 monitoring wells clustered in nine locations around the landfill. The originally proposed locations of the well clusters (1-9) were approximately as shown on Figure 1-7, except Clusters 8 and 9 which were originally to be constructed further west and north. The originally proposed depths of the borings and monitoring wells are detailed in Table 1-4. The ground water monitoring installation program was designed to develop essential information regarding site stratigraphy, to concentrate monitoring wells in areas where ground water contamination is suspected, and to delineate the vertical extent of contaminated ground water zones. Prior to the installation of monitoring wells, a boring

TABLE 1-4

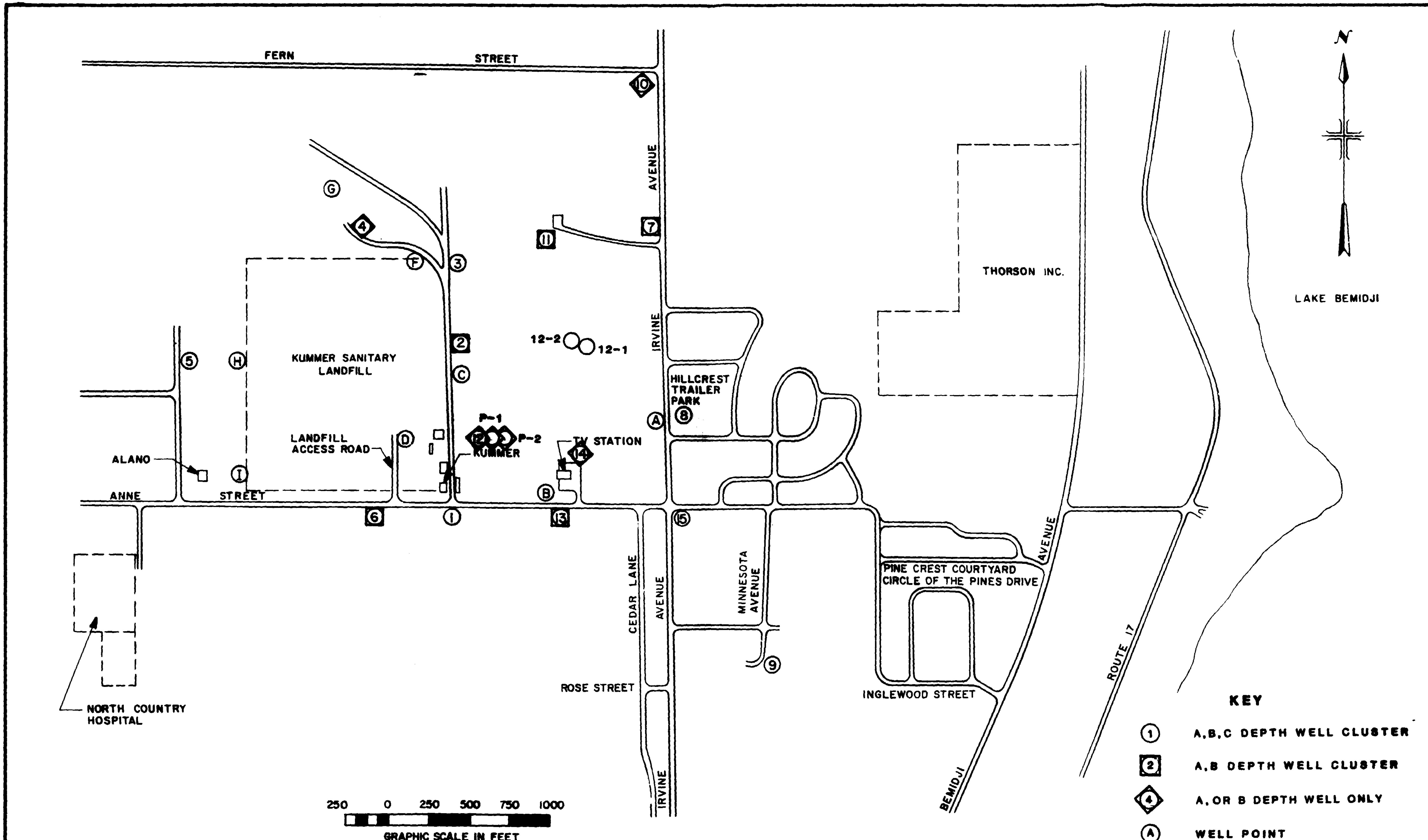
BORING AND WELL DEPTHS PROPOSED FOR RI
KUMMER LANDFILL REMEDIAL INVESTIGATION

Well Cluster Location	Total Estimated Boring Depth (ft)	Estimated Well Completion Depths (ft)		
		"A"	"B" b/	"C" c/
1	60	25	40	60
2	40	25	40	--
3	60	25	40	60
4	25	25 a/	--	--
5	60	25	40	60
6	40	25	40	--
7	40	25	40	--
8	60	25	40	60
9	60	25	40	60
Totals	445	225	320	300

a/ Split-spoon sampling at 5-foot depth intervals from 0 to 25 feet below grade.

b/ Split-spoon sampling every 5 feet from 0 to 40 feet below grade.

c/ Continuous split-spoon sampling from 40 to 60 feet below grade.



Base map from orthophoto flown in 1985.
Wells surveyed in 1986, 1988.

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION MINNESOTA POLLUTION CONTROL AGENCY	MONITORING WELL LOCATIONS	MALCOLM PIRNIE, INC. FIGURE 1-7

was to be installed in each cluster. Soil samples were to be obtained using two foot long split-spoon samplers at two to five feet intervals depending on the soil conditions. The soil samples were to be used to characterize and describe stratigraphy and soil. In addition, each soil sample was to be scanned with an organic vapor analyzer (OVA) or photoionization detector to detect volatile organic compounds in order to qualitatively access the vertical distribution of contaminants.

4. Water Level Surveys - Water level measurements were to be taken from all monitoring wells so that water table contour maps could be prepared for all aquifer zones adjacent to the landfill.

5. Air Monitoring - Ambient air monitoring around work sites was to be conducted during field investigations with a portable OVA for site health and safety requirements.

6. Monitoring Well Sampling - Ground water samples were to be collected in three rounds in order to determine what contaminants, if any, are migrating from the site, whether they have migrated as far east as Irvine and Minnesota Avenues, and the vertical depth of contamination. The sampling and the associated analyses were to be conducted in a step-wise fashion so that the level of analyses was minimized to a still adequate level. The first round of samples was to be collected from the newly installed wells around the perimeter of the landfill (clusters 1-6, 14 wells). The exact scope of sampling for the second and third rounds was unspecified since they depended on the analytical results of the preceding round. The Work Plan proposed instead that just prior to conducting Rounds 2 and 3, a sampling and analytical program for each of those rounds be prepared describing an appropriate sampling regimen for that round based on earlier analytical results. The

Round 2 and 3 sampling and analytical programs were then to be submitted to MPCA for review and approval. In addition to sampling monitoring wells, provisions were made to sample six different residential wells from the affected residential area around Cedar Street and Minnesota Avenue southeast and downgradient of the landfill during each of Rounds 2 and 3.

7. Surface Water and Sediment Sampling - The Work Plan proposed to collect three surface water samples from a ponded area north of the landfill and the south and west drainage ditches around the landfill. Sediment samples were also to be collected at each of those locations.

8. Analyses - Analytical parameters for all samples from the proposed monitoring wells, residential wells, surface water, and sediment sampling sites were to include those contained in EPA's Hazardous Substance List (HSL). HSL analyses were performed in accordance with EPA's Contract Laboratory Program (CLP) procedures by CompuChem Laboratories, Inc., a CLP laboratory. Certain water quality parameters were also proposed for analysis in order to help characterize ground water quality in the vicinity of the Kummer Landfill. These parameters included pH, alkalinity, dissolved oxygen, various nitrogen compounds (TKN, nitrate, nitrite, ammonia), carbon dioxide, and redox potential. Full HSL scans were proposed for Round 1 analyses. The level of analyses of Rounds 2 and 3 was to be contingent on earlier analyses. The intent was to limit subsequent analyses to those HSL fractions in which contaminants were already found to be present. Following receipt of results from Round 1, the data was to be evaluated along with the stratigraphic data generated during the soil monitoring. An analytical program for Round 2 described in Item 6 above was then to be developed. Following receipt and review of Round 2 data, a

Round 3 program was to be developed in the same manner. Justification for selecting certain wells for sampling and for the HSL fractions to be analyzed in each sample was to be provided. Sampling and analytical methodologies were to be the same as those in Round 1 and were to be consistent with the QAPP.

9. Data Validation - The Work Plan stated that data generated during the RI would be validated in terms of its accuracy, precision, sensitivity, comparability, and completeness for meeting the objectives of the RI stated in the QAPP.

10. Contamination Assessment - A contamination assessment was proposed to determine the severity of hazards at and around the site and the transport mechanism under which migration from the site occurs or may be allowed to occur. This assessment was to be based on background information and data generated during RI field activities. The necessity for remedial action was to be determined and based on several factors, including the types and quantities of contaminants present and their potential for migration. Actual or potential risk to human health and welfare and the environment was to be considered in this determination.

11. Public Health Assessment - An assessment of actual and potential risks posed to public health was proposed in the Work Plan following completion of RI field activities. It was acknowledged that an Endangerment Assessment, dated April 1985, for this site was developed by the Minnesota Department of Health (MDH). The MDH Assessment was to be considered in the preparation of the Public Health Assessment. Findings of the Contamination Assessment were to be used to develop the Public Health Assessment. In particular, these findings were to include the type of contaminants released from the site and their environmental fate. The Public Health Assessment was to address the type and concen-

trations of contaminants detected in the aquifer which have been released from the site, the ultimate fate of the contaminants migrating from the site, the points of human contact with the contaminants and the type and severity of health risks posed by such contact. Comparisons were to be made to the State of Minnesota drinking water standards.

12. Environmental Assessment - An Environmental Assessment was proposed in the Work Plan to evaluate the impact of contaminants found in the aquifer on the local environment. This assessment was to be performed in conjunction with the two assessments mentioned above upon completion of RI activities. The Environmental Assessment was to identify the chemicals present in the aquifer, the concentrations and exposure levels of the contaminants, and the methods and significance of environmental exposure.

13. Remedial Investigation Draft and Final Reports - The Work Plan stated that the RI Draft and Final Reports will be prepared at the conclusion of the Remedial Investigation and will be based on data generated during the initial phase of the investigation. The reports include reduced data for analytical results, test borings, and logs, and other field and laboratory results. They will also include detailed descriptions of the types of hazardous substances, pollutants, or contaminants found at the site; any medium (e.g., ground water, surface water, soils, air) affected by the hazardous substances, pollutants or contaminants at the site; the pathways (e.g., leachate, multi-aquifer wells, runoff) by which hazardous substances, pollutants, or contaminants reached the media; and, the extent and magnitude of hazardous substances, pollutants or contaminants in the ground water beneath and around the site. The data is presented on cross sections, isopleth maps, graphs, tables and in narra-

tive form. The Contamination Assessment, Public Health Assessment and Environmental Assessments described above in Sections 6.10, 6.11 and 6.12 are also to be presented in the RI Draft and Final Reports. A list of possible alternative response actions identified in Chapter 1 - Evaluation Report is included in the report as approved or modified with discussions designed for further refining and evaluation of the list if the remedial investigation has produced sufficient information to allow for a detailed analysis of those alternatives.

1.8 REMEDIAL INVESTIGATION

1.8.1 History

The Kummer RI/FS Work Plan exclusive of the Quality Assurance Project Plan was approved by MPCA on September 23, 1986. This approval authorized Malcolm Pirnie to begin the drilling program. However, sampling and analytical activities were not authorized to proceed until the QAPP was approved by MPCA and EPA on November 26, 1986. Approving the other chapters of the Work Plan early enabled the drilling program to commence in October, 1986 prior to the onset of adverse winter weather. Supplemental remedial investigation activities were approved by MPCA on October 23, 1987 and commenced in January 1988. A chronology of significant remedial investigation activities is given in Appendix C.

1.8.2 Departures from the Work Plan

The most significant departure from the technical approach given in the Work Plan was the method of well installation. The method of drilling proposed in the Work Plan assumed that a till layer existed below the area of the site at a depth of approximately 45 feet below ground surface. As a result, the shallow (or "A") wells were to be screened at the top of the upper aquifer, the mid-depth (or "B") wells were to be screened just above the till layer in the upper aquifer, and the deep (or "C") wells were to be cased through the upper aquifer and screened in the upper zone of the lower aquifer.

At the start of the drilling program, it became evident that augering could not be continued through the completion of the deep borings due to heaving sands. After consultation with MPCA personnel, a decision to continue drilling with bentonite fluid (mud rotary) was made. By drilling with fluid having a hydrostatic pressure greater than that in the bore hole, hydrostatic forces would prevent movement of formation material into the hole effectively sealing any contamination in the upper zone. Using the bentonite fluid, therefore, eliminated the need for casing the upper aquifer thereby reducing overall drilling costs. This decision to deviate from the Work Plan was reinforced soon after additional borings were made which showed that the till layer was not continuous over the entire site area. This eliminated any necessity to maintain segregation of what was originally assumed to be a two aquifer system.

Other departures from the Work Plan which concerned the drilling program included the following: 1) a shallow monitoring well only instead of a shallow and mid-depth monitoring wells was installed at location 4 since it was learned that there was no major northward component of ground water flow at that location; 2) monitoring well clusters 8 and 9 were repositioned slightly to the east and south, respectively, in order to take advantage of better ground surface location features.

Other departures from the Work Plan involved slight revisions to the number of residential wells sampled. One fewer residential well was sampled than originally intended in Round 2 and two more wells were sampled in Round 3. Also, no surface water samples were collected due to the lack of rainfall during the field investigation as evidenced by official rainfall observations for the area which are reported to have been 0.28 inches for October and 1.07 inches for November 1986. This is about 1.03 inches below normal for the two month period.

Slug tests specified in the Work Plan were not conducted because it was concluded that they would not provide meaningful information due to the highly transmissive sands at the site. Well points at the site were not abandoned because it was determined that they were not serving as a conduit for contaminant migration and because they provided satisfactory water level elevation sampling locations.

1.8.3 Remedial Investigation Summary

Notice to proceed with the drilling program of the Kummer remedial investigation was issued on September 23, 1986. The drilling program commenced on October 7, 1986 and concluded on November 5, 1986. Nine deep borings were installed to depths reaching 108 feet at nine monitoring well cluster locations shown on Figure 1-7. Twenty-two monitoring wells were installed at those nine sites in clusters of one to three wells of various depths. Cluster wells 1 through 6 were located around the perimeter of the landfill. Cluster No. 5 was termed the upgradient location. Cluster Nos. 1, 2, and 3 were considered immediately downgradient locations. Cluster Wells Nos. 7, 8, and 9 were located east or further downgradient of the landfill along Irvine and Minnesota Avenues.

Sampling of the twenty-two monitoring wells and fourteen selected residential wells generally located southeast of the landfill was conducted over three sampling rounds. Round 1 entailed sampling cluster 1 through 6 cluster wells and submitting all for full HSL and WQP analyses. Round 2 included resampling cluster wells 1 through 6 for volatile HSL analyses only and sampling of Cluster Wells 7, 8, and 9 and five residential wells for full HSL and WQP analyses. Round 3 concluded the sampling with a resampling of the Cluster 7, 8, and 9 wells and sampling of ten residential wells for volatile HSL analyses, and three sediment samples for full HSL analyses.

1.8.4 Supplemental Remedial Investigation Summary

A supplemental Remedial Investigation work plan was submitted to MPCA on October 1, 1987 and approved on October 23, 1987. The supplemental drilling program commenced on January 14, 1988 and concluded on February 12, 1988. Additional supplemental work, including a pumping test, slug tests, and sampling Rounds 4 and 5, was conducted during February and March, 1988.

A total of 10 new wells and 2 piezometers were installed during the supplemental program. Locations for the well clusters were selected to provide geologic and water quality data that would complement data from the original monitoring well network. All of the wells were located downgradient of the landfill.

Samples were collected from all monitoring wells during Round 4 sampling. Round 5 sampling included all wells in Clusters 5 and 7 through 15. All samples from both rounds were analyzed for volatile fraction HSL compounds. Results from Round 5 sampling are not yet available. Round 6 sampling has not been completed as of this writing.

1.9 SCOPE OF THIS REPORT

This report includes the following sections:

2.0 SITE FEATURES

2.1 DATA SOURCES

Review of the existing database included a search of published material at the University of Minnesota libraries, the Minnesota Geological Survey (MGS) well log files and publication lists, the Minnesota Pollution Control Agency's (MPCA) Solid and Hazardous Waste Division files, the report files of the U.S.G.S. offices and the files of Leggette, Brashears and Graham, Inc. In addition, information developed during the preliminary field reconnaissance including interviews with Mr. & Mrs. Charles Kummer, an inspection of the site and surrounding environs, meetings with MPCA personnel (Messrs. Larry Olson, Bruce Nelson, and Stephen Riner), and correspondence with R.E. Rolling of the Beltrami County Soil Survey was included. A list of maps, technical reports and personal communications which were used in preparation of the Evaluation Report is included at the end of this section under "Selected References."

An additional important source of information for the findings discussed in this report is the boring program conducted as part of the Kummer remedial investigation. Information regarding subsurface stratigraphy from split-spoon sampling was extremely important in defining subsurface soil conditions in the vicinity of the site. Ground water level measurements taken from the previously existing well-points and the newly installed monitoring wells was also helpful in determining ground water flow gradients.

2.2 REGIONAL PHYSIOGRAPHY

The Kummer Sanitary Landfill is located in Northern Township in South-Central Beltrami County. Figure 1-2 provides a regional map around the Kummer site. This area is characterized by flat to gently rolling terrain to the north and gently rolling terrain to the south. Surface elevations range from approximately 1,050 to 1,550 feet above mean sea level.

Numerous wetlands and lakes are found in the area. Prior to agricultural drainage, one-half of Beltrami County was composed of wetland. Many bogs and peat deposits indicate the wetland history of the area (Todd, 1899). Regional drainage is to the south. Lake Bemidji drains east to Cass Lake via the Mississippi River. The site lies within the upper drainage basin of the Mississippi River.

Black, red, and white pine forests (with lesser deciduous stands containing poplar, aspen, basswood, elm, birch and maple) covered the county prior to agricultural settlement and lumbering. Today, much of the woodland is planted pine, with some reforestation by aspen, birch, spruce and white pine (Todd, 1899). Mineral resources of the county consist primarily of aggregate (sand and gravel) and peat. Sand and gravel borrow pits are common in the vicinity of the site.

2.3 LOCAL PHYSIOGRAPHY

The landfill property is over 40 acres in area. The site is bounded on the east and west by pasture and/or grain cropland, on the north by woodlands and a bog, and on the south by planted pine woods and a gravel pit. Approximately 30 to 35 acres of the site have been landfilled. The extreme northern portion of the site has been the source of borrow material for daily landfill cover. To the north and west of the site the land is sparsely settled with farm residences and other isolated buildings. The closest residential building is the Kummer residence located on-site in the extreme southeast corner of the property. A large residential community lies approximately 1,000 feet further to the east and south. This area includes Hillcrest Manor Trailer Park, Anne Street, Cedar Lane, Irvine Avenue, Minnesota Avenue, Tamarack Avenue, Bemidji Avenue, and several smaller streets. No buildings are located within 3,000 feet directly south of the landfill. North Country Hospital is located directly southwest of the site at the corner of Pine Ridge Avenue and Anne Street. The Sandy Hills Acres subdivision borders the western edge of the landfill property. Greenleaf Avenue of this subdivision lies within 500 feet of the landfill. Presently only one home has been built in Sandy Acres, although unimproved roadways have been constructed. The single home is at the southeast corner of Greenleaf Avenue and Anne Street along the western side of the landfill.

The terrain is very gently rolling. Surface elevation at the site ranges from about 1,360 to 1,380 feet above MSL. Local surface drainage is generally northward. Approximately one-half mile to the north a modified stream channel or ditch carries runoff eastward to Lake Bemidji.

2.4 REGIONAL HYDROLOGY

The Kummer Sanitary Landfill is located in the Mississippi River Headwaters Watershed. Water Resources in the area are considered abundant with lakes and streams occupying about 8 percent of the regional surface area. Ground water supplies are available from the glacial drift. In some areas domestic water supplies may be obtained from the bedrock (Oakes and Bidwell, 1968). The Mississippi River, many of its tributaries, headwaters, reservoirs and numerous lakes provide water suitable in quantity and quality for most industrial, municipal, agricultural, and recreational uses. Stream flow is fairly regular because of storage in lakes, swamps, and glacial deposits. Control structures have been established to maintain uniform water levels. Average annual runoff from the watershed is about 5.34 inches. Lake surface evaporation is about 2 inches per year.

2.5 REGIONAL HYDROGEOLOGY

The ground water reservoir contains the largest quantity of water available within the area. Ground water discharge provides at least part of the base flow of streams and uniform lake stages. Ground water yields of up to 500 gpm are available from outwash deposits providing sufficient amounts for many municipal, industrial, and agricultural needs. Outwash deposits underlying present surface water courses provide the best source of groundwater supply. Some ground water is also available from buried valleys filled with glacial deposits and from Precambrian sedimentary rock. Saturated thickness of glacial deposits range from 50 to 500 feet (Oakes and Bidwell, 1968).

Ground water quality is typically represented by hardness values from 68 mg/l to 200 mg/l. The sum of iron and manganese concentrations ranges from 0.02 to 7.80 mg/l. The ground water quality makes this resource suitable for irrigation purposes (Oakes and Bidwell, 1968).

Ground water use in the Bemidji area is limited to the unconsolidated deposits above bedrock. The bedrock formations are not considered to yield water in sufficient quantities for municipal, agricultural or industrial use. Some ground water, sufficient for domestic purposes, may be available from the weathered upper surface of the Precambrian bedrock and from faults and fractures (Kanivetsky, 1978). The City of Bemidji primary water supply wells are located one and one-quarter miles west of the site and are pumped from a depth of about 160 feet. Older municipal wells are located about one-half mile south of the site and extend to a depth of between 83 and 208 feet.

2.6 CLIMATOLOGY

Climate in this region is temperate. The National Oceanic and Atmospheric Administration compiled climatic data from the Bemidji Airport (one and one-half miles west of the site) for the period 1941 to 1970 (Hult, 1984). These data indicate an annual average temperature range of -16°C (+3.2°F) in January to 20°C (68°F) in July. Precipitation is moderate, 22.25 inches annually with 10.5 inches of this amount occurring as rain in June, July, and August. During the period November through March, 3.2 inches fall as snow. Most of this moisture is held in storage as snow until the spring thaw allowing recharge of the ground water table as well as runoff to surface water bodies. The report by Oakes and Bidwell (1968) states that annual precipitation in this region is 25.33 inches. This value includes 5.34 inches of surface runoff, 0.01 inch of ground water underflow, an estimated storage of 0, and 19.98 inches of evapotranspiration. The precipitation value provided by Hult is probably more accurate for this site. The information from Oakes and Bidwell is included because it is the only source of information found for runoff, underflow, and evapotranspiration.

2.7 DEMOGRAPHIC SETTING

The Kummer Sanitary Landfill is located in Northern Township along the township's southern border with the City of Bemidji. Northern Township has a population of 4,095 (1986 data) and is generally sparsely populated. The township is largely undeveloped with large tracts of forests, open land, and wetlands. Most of the township's residents live in the southeastern section of the town near Bemidji and along the western shore of Lake Bemidji.

Land use in the immediate vicinity of the landfill is primarily residential. Single family homes are found on adjacent Anne Street, and nearby Irvine, Cedar, and Minnesota Avenues; approximately 125 trailer homes are located in the Hillcrest Trailer Park located 1,500 feet directly east of the landfill on Irvine Avenue. Besides the trailer homes, it is estimated that 175 to 200 homes are located in an area bounded on the south by 30th Avenue (2,750 feet south of the landfill), on the east by Bemidji Avenue (generally 4,000 feet east of the landfill), on the north by Fern Road (1,250 feet north of the landfill), and on the west by U.S. Highway 71 (approximately 1,750 feet east of the landfill).

Several commercial properties are located within this area. These include the North Country Community Hospital located immediately southwest of the landfill on Anne Street, the Thorson, Inc. gravel pit located on the west side of Bemidji Avenue, approximately 4,000 feet directly east of the landfill, and several smaller businesses such as gas stations and convenience stores.

The City of Bemidji has a population of 11,088 (1986 data). The city is a retail sales center for north-central Minnesota. Other primary industries include forest products, agriculture, and tourism. Bemidji State University with an enrollment of 4,000 students is also located in the City.

3.0 GEOLOGIC AND HYDROGEOLOGIC SETTING AND INVESTIGATIONS

3.1 REGIONAL GEOLOGY

3.1.1 Bedrock

Bedrock is Precambrian Era in age and is described by Sims (1970) as igneous felsic intermediate intrusive rocks. The rock types "are largely inferred from gravity and aeromagnetic data; age uncertain, in areas south of Lake of the Woods, includes some gneisses" (Sims, 1970). Regional NW-SE trending fault traces are present a few miles to the north and west of Bemidji. According to the Bedrock Hydrogeology map of Minnesota by Kanivetsky (1978), these faults do not extend beneath the site.

The Bedrock Topography Map of Minnesota (Olsen and Mossler, 1982) is incomplete in this region. A few drill hole bedrock depths and outcrops are available for central Beltrami County and central Hubbard County. A drill hole about 10 miles northeast of the landfill site encountered bedrock (bedrock type not indicated) at a depth of about 530 feet below ground surface. Other bedrock elevations about 25 miles north of the site range from about 250 to 350 feet below the surface (based on data from five drill holes). Two drill holes about 20 miles south of the site in Hubbard County indicate bedrock depths of 200 to 400 feet below the surface (these two holes are only about three miles apart).

3.1.2 Unconsolidated Deposits

The unconsolidated sediments in this area consist of clays, silts, sands, and gravels deposited during the Late Wisconsin Glacial Period. The glacial deposits of Beltrami and Hubbard Counties range from undifferentiated outwash of the Des Moines Lobe (Late Wisconsin Age) to older ground and end moraines of the Wadena Lobe of the Early to Late Wisconsin Age (Minnesota Geological Survey, 1982). These deposits are highly variable, as indicated in the following citation from Oakes and Bidwell (1968):

"Glacial Deposits in the watershed include till, lenses of sand and gravel in till, outwash deposits of sand and gravel, and lake deposits of fine sand, silt and clay."

Limited site specific information on the geology was found in MPCA and MGS files. Review of available published literature indicates that the site is underlain by glacial outwash (deposits of sand and gravel mixed with some silt and clay, and with interbedded layers of sand and gravel laid down by glacial melt water streams [Kanivetsky, 1979]).

Samples of the cover material and subsurface deposits were examined at the site during the preliminary reconnaissance. Except for isolated areas where clay topsoil is used, the landfill cover material is derived from the sand and gravel glacial outwash found on-site and is, therefore, very permeable. Glacial outwash samples from the bottom and sides of borrow trenches used for cover material along the northern edge of the landfill show a medium brown to reddish brown sand with 10 to 30 percent medium size to coarse size gravel. Individual sand and gravel grains are mostly white or clear quartz with some brown and/or red feldspar grains giving the soils an overall color of medium to reddish brown. Shallow hand auger borings performed at the site indicate find sand to a depth of approximately 20 feet (Sunde, 1980).

Excerpts from a report by Gerald Sunde, (1980) provide some details concerning the glacial deposits immediately beneath the land fill (brackets indicate remarks by current writer): "These shallow well [hand auger borings] showed fine sand to the water table [15 to 25 feet]."

Well logs for domestic wells located within two or three miles of the site indicate the top of a clay layer at a depth of 36 to 45 feet bgl. The thickness of this layer is uncertain, however, it appears to range from 1 to 60 feet. Sunde (1980) reports that borings conducted during construction of the North Country Hospital located one quarter mile southwest of the site extended to maximum depths of 42 feet. The borings show medium to fine grained sands with a little gravel throughout the boring depth except in a thin layer of silty clay at about 30 feet.

Soil conditions at these hospital borings should be reasonably comparable to those at the landfill site due to their proximity, similar topography, surface soil types, and mechanics of deposition.

3.2 SITE-SPECIFIC GEOLOGIC INVESTIGATIONS

3.2.1 Objective and Rationale

The objectives of the geologic investigation conducted as part of the Kummer remedial investigation remained unchanged from those outlined in the Work Plan and restated in Section 1.7 of this report. A supplemental objective can be added to those which was to gain site-specific hydrogeologic information in order to more fully understand the transport (or migration) mechanism by which contamination is moved from the site. The objectives and rationale developed for the Kummer geologic investigation are given in Table 3-1.

3.2.2 Original Boring and Monitoring Well Program

A ground water monitoring program was commenced in November, 1986, to investigate any ground water contamination resulting from landfill operations at the Kummer site. Nine well sites were chosen to monitor points up and downgradient of the landfill, as well as downgradient of known areas of ground water contamination.

Two or three wells of varying depth were installed at all but one site (MW-4). "Clustering" wells in this manner allowed for monitoring of ground water in more than one stratigraphic zone. At the Kummer Landfill, the shallow "A" wells were placed to bridge the water table. The intermediate depth "B" wells were placed below any possibly confining clay layers and above any occurrence of till. The deeper "C" wells were screened below the till.

The boring for the deepest well in any cluster was installed first. Mud-rotary drilling was employed on "B" and "C" wells, which allowed for subsoil sampling with a two-inch split-spoon sampler alongside the bit of the drill rods. Soil types were noted and logged. Samples were also screened with an HNu photoionization detector for volatile organic contamination.

TABLE 3-1

OBJECTIVES AND RATIONALE FOR RI GEOLOGIC INVESTIGATION
KUMMER LANDFILL REMEDIAL INVESTIGATION

	OBJECTIVE	RATIONALE	MEANS OF ACCOMPLISHING
1.	Develop information regarding site stratigraphy	- to determine location, characteristics, and depths of aquifers of concern - to determine susceptibility of aquifers to contamination - to determine locations of aquicludes	- deep soil borings and split-spoon sampling of soil samples
2.	Concentrate wells in areas where groundwater contamination is suspected	- to identify maximum concentrations of contaminants	- installation of monitoring wells immediately down-gradient of landfill
3.	Delineate vertical extent of contamination	- to determine whether different zones of the aquifer(s) of concern are contaminated	- clustering of monitoring wells of varying depth at the same location - sampling of monitoring wells and analyzing groundwater samples
4.	Develop site-specific hydrogeologic information	- to understand transport mechanism of contaminants - to determine locations of potable wells at risk	- soil borings/split-spoon sampling to understand site stratigraphy - groundwater level observations - groundwater sampling and analysis - conduct pumping and slug tests

Subsoil core samples were initially field screened with the HNu by passing the intake tube over the core immediately after opening the split spoon sampler and by splitting the core sample in half and again passing the HNu intake tube over the newly exposed surfaces. Additional screening of the subsoil samples was accomplished using headspace methods. The jars containing the samples were stored for a period of a few hours to one day then opened slightly and the HNu intake tube was inserted under the lid of the jar. Any detection of volatile organics was noted.

When the boring was complete, schedule 10 stainless steel casing was installed with 0.020 slot stainless steel screen in five-foot lengths. Two-inch casing was used for the "B" wells and 4" casing for the "C" wells. The drilling fluid was then flushed out of the hole with clean water. "Eau Claire" #30 silica sand was packed to at least one foot above the top of the screen with a 1 to 2-foot bentonite pellet seal above the sand. The remaining annular space was backfilled with grout, and a locking steel cap affixed to the casing.

The stratigraphic information obtained from this boring was then used to place the remaining wells in the cluster at appropriate depths. The "A" wells were installed using a hollow-stem auger without use of a drilling fluid. Well construction was the same as for the "B" wells, except ten feet of screen was used to allow continued bridging of the water table during seasonal fluctuations. Monitoring well construction data is given in Appendix D and boring logs are given in Appendix E. Table 3-2 gives physical data for the wells installed.

Eight well-points previously installed at the landfill were investigated to determine their degree of connection with the water table. Physical data regarding the well points is given in Table 3-3. Well points were bailed sufficiently to remove several well volumes, with water levels taken immediately before and after evacuation. No change in water level was detected in any well point, indicating that they are in adequate communication with the water table for use as water level monitoring points.

TABLE 3-2

MONITORING WELL DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION

Well No.	Well Diameter (inches)	Top of Casing Elevation (ft above MSL)	Ground Elevation (ft above MSL)	Screen Length (ft)	Screen Depth (ft BGL)	Screen Elevation (ft above MSL)	Total Boring Depth (ft BGL)
1A	2	1379.65	1378.38	10	17.0 - 27.0	1351.38 - 1361.38	27
1B	2	1379.50	1378.43	5	40.5 - 45.5	1332.93 - 1337.93	45.5
1C	4	1379.65	1378.34	5	56.7 - 61.7	1316.64 - 1321.64	63
2A	2	1373.44	1371.94	10	14.0 - 24.0	1347.94 - 1357.94	25
2B	2	1373.39	1372.03	5	31.5 - 36.5	1335.53 - 1340.53	41
3A	2	1368.03	1366.35	10	4.0 - 14.0	1352.35 - 1362.35	14
3B	2	1367.58	1366.07	5	24.5 - 29.5	1336.57 - 1341.57	29.5
3C	4	1367.91	1366.04	5	40.5 - 45.5	1320.54 - 1325.54	63
4A	2	1368.14	1365.91	10	5.2 - 15.2	1350.71 - 1360.71	15.2
5A	2	1372.97	1370.96	10	7.2 - 17.2	1353.76 - 1363.76	17.2
5B	2	1373.32	1371.03	5	30.0 - 35.0	1336.03 - 1341.03	35
5C	4	1372.94	1370.95	5	87.5 - 92.5	1278.45 - 1283.45	108
6A	2	1380.86	1379.30	10	17.0 - 27.0	1352.30 - 1362.30	27
6B	2	1380.72	1379.24	5	40.3 - 45.3	1333.94 - 1338.94	80
7A	2	1355.86	1353.95	10	4.7 - 14.7	1339.25 - 1349.25	14.7
7B	2	1355.96	1354.04	5	33.3 - 38.3	1315.74 - 1320.74	61.5
8A	2	1369.80	1367.81	10	12.4 - 22.4	1345.41 - 1355.41	22.4
8B	2	1369.95	1367.88	5	33.0 - 38.0	1329.88 - 1334.88	38
8C	4	1369.59	1367.66	5	99.0 - 104.0	1263.66 - 1268.66	106
9A	2	1372.40	1370.74	10	15.8 - 25.8	1344.94 - 1354.94	27
9B	2	1372.36	1370.55	5	32.5 - 37.5	1333.05 - 1338.05	37.5
9C	4	1372.33	1370.49	5	67.0 - 72.0	1298.49 - 1303.49	77

TABLE 3-2

MONITORING WELL DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Well No.	Well Diameter (inches)	Top of Casing Elevation (ft above MSL)	Ground Elevation (ft above MSL)	Screen Length (ft)	Screen Depth (ft BGL)	Screen Elevation (ft above MSL)	Total Boring Depth (ft BGL)
10A	2	1355.37	1352.12	10	3.0 - 13.0	1339.12 - 1349.12	17
11A	2	1361.93	1358.79	10	5.0 - 15.0	1343.79 - 1353.79	15
11B	2	1361.16	1358.79	5	23.0 - 28.0	1330.79 - 1335.79	42
12B	6	1376.92	1374.10	30	16.0 - 46.0	1328.10 - 1358.10	47
P-1	2	1376.45	1373.53	24	21.0 - 45.0	1328.53 - 1352.53	45
P-2	2	1375.12	1372.61	24	21.0 - 45.0	1327.61 - 1372.61	45
13A	2	1367.35	1364.05	10	5.0 - 15.0	1349.05 - 1359.05	15
13B	2	1367.03	1364.05	5	42.5 - 47.5	1316.55 - 1321.55	62
14A	2	1379.06	1376.88	10	14.0 - 24.0	1352.88 - 1362.88	27
15A	2	1377.43	1374.57	10	20.0 - 30.0	1344.57 - 1354.57	30
15B	2	1377.48	1374.57	5	33.5 - 38.5	1336.07 - 1341.07	50
15C	4	1377.16	1374.54	5	48.0 - 53.0	1321.54 - 1326.54	62

Note:
BGL = Below Grade Level
MSL = Mean Sea Level

TABLE 3-3

WELL POINT DATA
KUMMER LANDFILL REMEDIAL INVESTIGATION

Well Point No.	Relative Position in Cluster	Diameter (inches)	Top of Casing Elevation (ft above MSL)	Ground Elevation (ft above MSL)	Screen Length	Screen Depth	Total Well Depth (ft BGL)
A	Single	1.25	1373.02	1370.90	unknown	unknown	21.20
B	Single	1.25	1373.47	1370.86	unknown	unknown	21.20
C	Single	1.25	1376.40	1375.30	unknown	unknown	23.10
D	Single	1.25	1378.11	1377.19	unknown	unknown	23.85
F	Single	1.25	1368.09	1364.73	unknown	unknown	18.12
G	Single	1.25	1368.19	1365.76	unknown	unknown	6.50
H	Single	1.25	1379.43	1376.66	unknown	unknown	23.20
I	Single	1.25	1378.91	1377.72	unknown	unknown	22.40
X (Miller)	Single	2	1349.21	1346.72	3	18 - 21	21
Y (Thorson)	Single	2	1348.76	1345.76	unknown	unknown	21

Note:
BGL = Below Grade Level
MSL = Mean Sea Level

3.2.3 Supplemental Boring and Monitoring Well Program

As part of the supplemental investigation conducted in January and February 1988 in the vicinity of the Kummer Landfill, ten new monitoring wells were installed along with two piezometers and two additional soil borings. The locations of the wells and borings are shown in Figure 1-7; construction details are summarized in Appendix D. Descriptive soil logs and graphic well construction logs are presented in Appendix E.

Because of a heaving sand problem encountered during the earlier RI, a combination of drilling methods were used. Split-spoon soil samples were collected through a 3-1/4-inch inside diameter (I.D.) hollow stem auger. To conduct the borings, the auger and pilot assembly were advanced first to the desired sampling depth. The pilot assembly was then withdrawn slowly from the hole while clean water was added to the inside of the auger in order to maintain a positive hydrostatic pressure at the bottom of the boring. After the pilot assembly was removed from the hole more water was added, if necessary, to compensate for the rate at which the formation was accepting fluid. The split spoon sampler and drilling rod were then set into the borehole and the soil sample collected.

After collection of the last soil sample in each boring, the hole was either abandoned or completed as a monitoring well. Soil borings were abandoned by pumping neat cement from the bottom to the top of the hole by means of a tremie pipe. The augers were removed as grout was added. Other soil borings were completed as wells by removing all of the 3-1/4-inch I.D. augers and then enlarging the boring by either mud rotary method or 6-1/4-inch I.D. hollow stem auger equipped with a knock out plate. All of the monitoring wells and piezometers except for MW-12B and MW-15C were completed by using the larger diameter hollow stem auger. Wells were constructed in the enlarged boring in the same manner as those installed during the initial RI.

A 24 hour pumping and recovery test was conducted on MW-12B to determine transmissivity of the upper zone of the water table aquifer. Slug tests were also conducted on some of the B and C wells in order to estimate variations in hydraulic conductivities in the area.

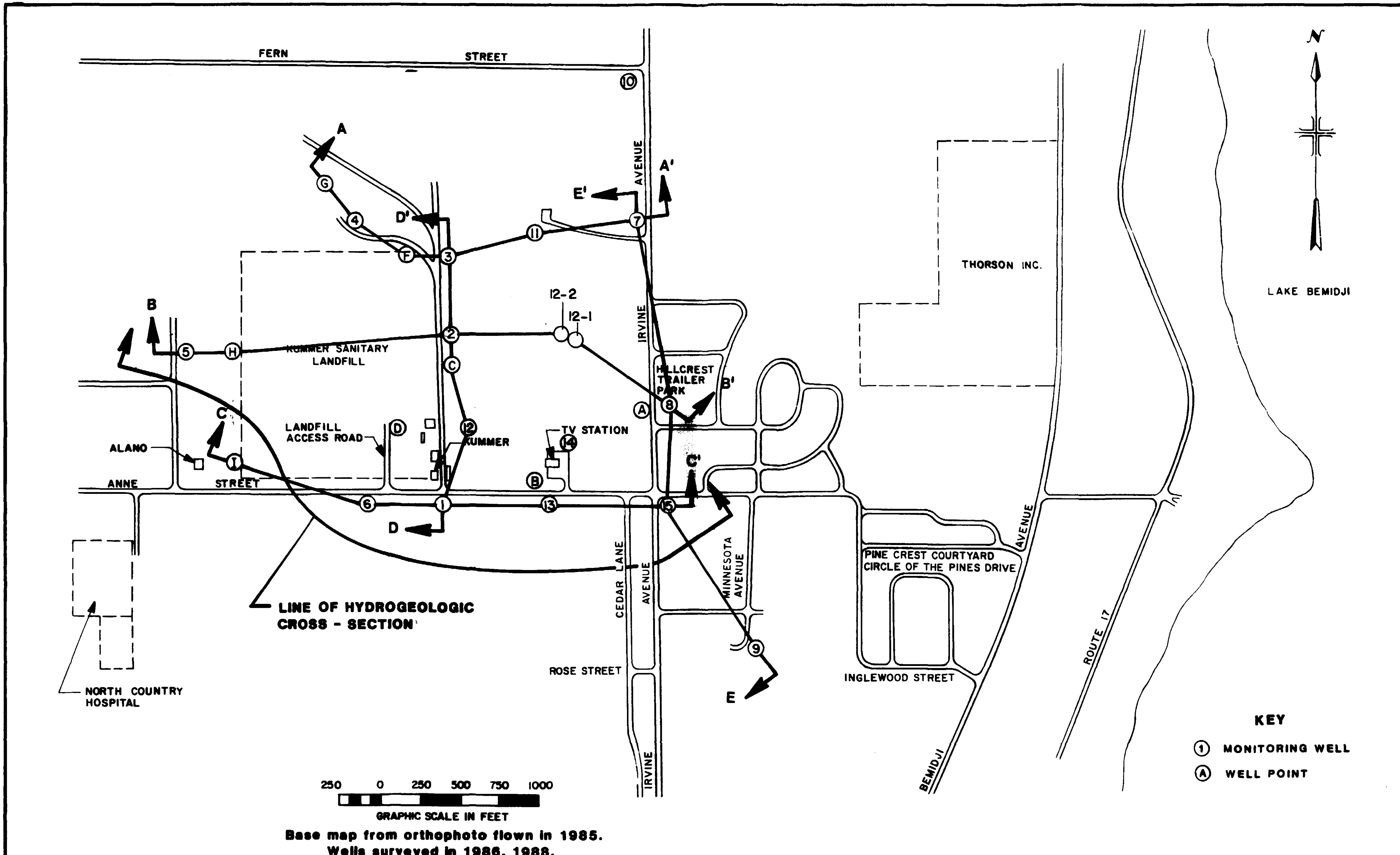
3.3 SITE-SPECIFIC GEOLOGY

The Kummer Landfill and surrounding area is underlain primarily by permeable glacial outwash sands deposited by meltwater streams flowing away from the front edge of a continental glacier. The sands encountered over most of the site are well-sorted, with individual grains being subangular to rounded. These characteristics are typical of material that has been transported by flowing waters. Sand and gravel lenses less than six feet thick and clay and/or silt lenses generally less than five feet thick are interbedded with these sands at some locations, and appear to be discontinuous. Five geologic cross sections are located on Figure 3-1 and are given on Figures 3-2 through 3-6. The drilling logs provided in Appendix E illustrate the site geology.

A body of low permeability glacial till underlies much of the area immediately east of the landfill. Till is a heterogeneous material deposited by a retreating glacier, consisting of unsorted and unstratified gravels, sands, silts and clays. Thickness of the till encountered during drilling varies from as little as five to ten feet up to almost sixty feet thick; in some areas it was not encountered the entire depth of the boring, to 1300 feet above msl. The depth at which the till occurs also varies, though the contact with the overlying sands is generally between 1325 and 1335 feet above msl. The block diagram on Figure 3-7 shows how the till body is situated in relation to the landfill. Cross-section E-E' (Figure 3-6) indicates that the till either does not extend as far south as MW-9 or is at a depth greater than the depth of the boring.

3.4 SITE SPECIFIC HYDROGEOLOGY

The glacial outwash sands are productive and provide most of the ground water in the area. The sands above the till, where



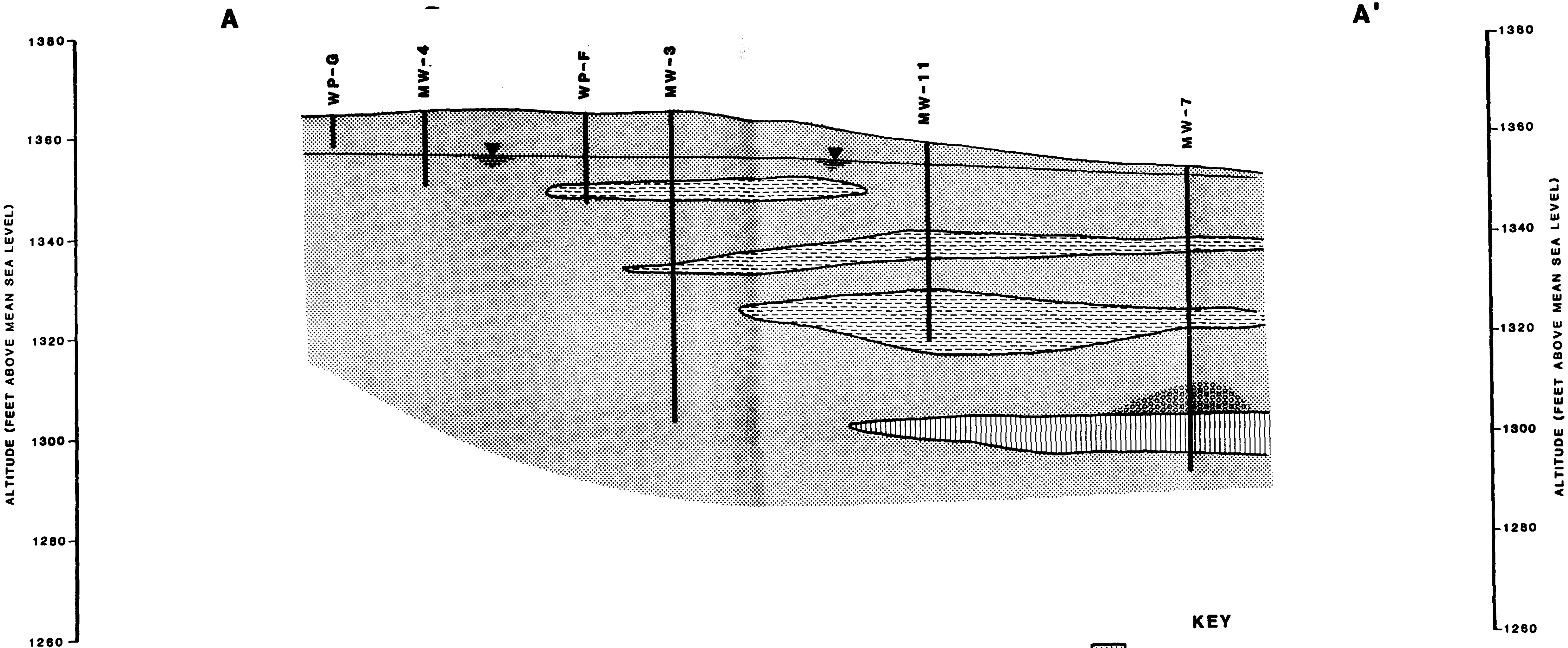
MALCOLM PIRNIE

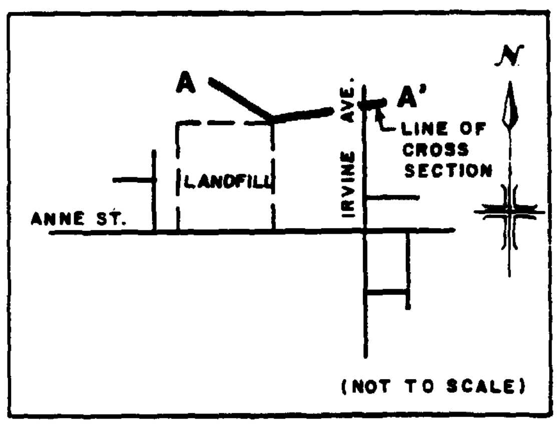
KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

LOCATION DETAIL MAP FOR LINES OF GEOLOGIC AND HYDROGEOLOGIC CROSS - SECTIONS

MALCOLM PIRNIE, INC.

FIGURE 3-1





LOCATION MAP

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=250'
VERTICAL EXAGGERATION= 12.5 X

NOTES:

1. THE LOCATION OF THE GEOLOGIC CROSS SECTION IS SHOWN ON THE LOCATION DETAIL MAP, FIGURE 3-1.
2. THE STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN WIDELY SPACED BORINGS. ACTUAL FIELD CONDITIONS MAY VARY FROM THOSE SHOWN.
3. GENERALIZED SOIL DESCRIPTIONS ARE SHOWN BETWEEN STRATUM LINES. FOR MORE DETAILED DESCRIPTIONS REFER TO ACTUAL WELL AND BORING LOGS.
4. GROUND WATER LEVELS WILL FLUCTUATE. FLUCTUATIONS IN LEVELS WILL RESULT FROM VARIATIONS IN RAINFALL, TEMPERATURE, SEASON AND OTHER FACTORS.
5. SHAPE AND DIMENSIONS OF LANDFILL AS SHOWN MAY NOT REFLECT ACTUAL CONSTRUCTION.

KEY

SAND
CLAY AND/OR SILT
GRAVEL
TILL (SAND, CLAY, GRAVEL)
LANDFILL
▼ WATER TABLE ELEVATION (TAKEN FEB. 16-18, 1988)
MW-1 MONITORING WELL NO.
WP-A WELL POINT

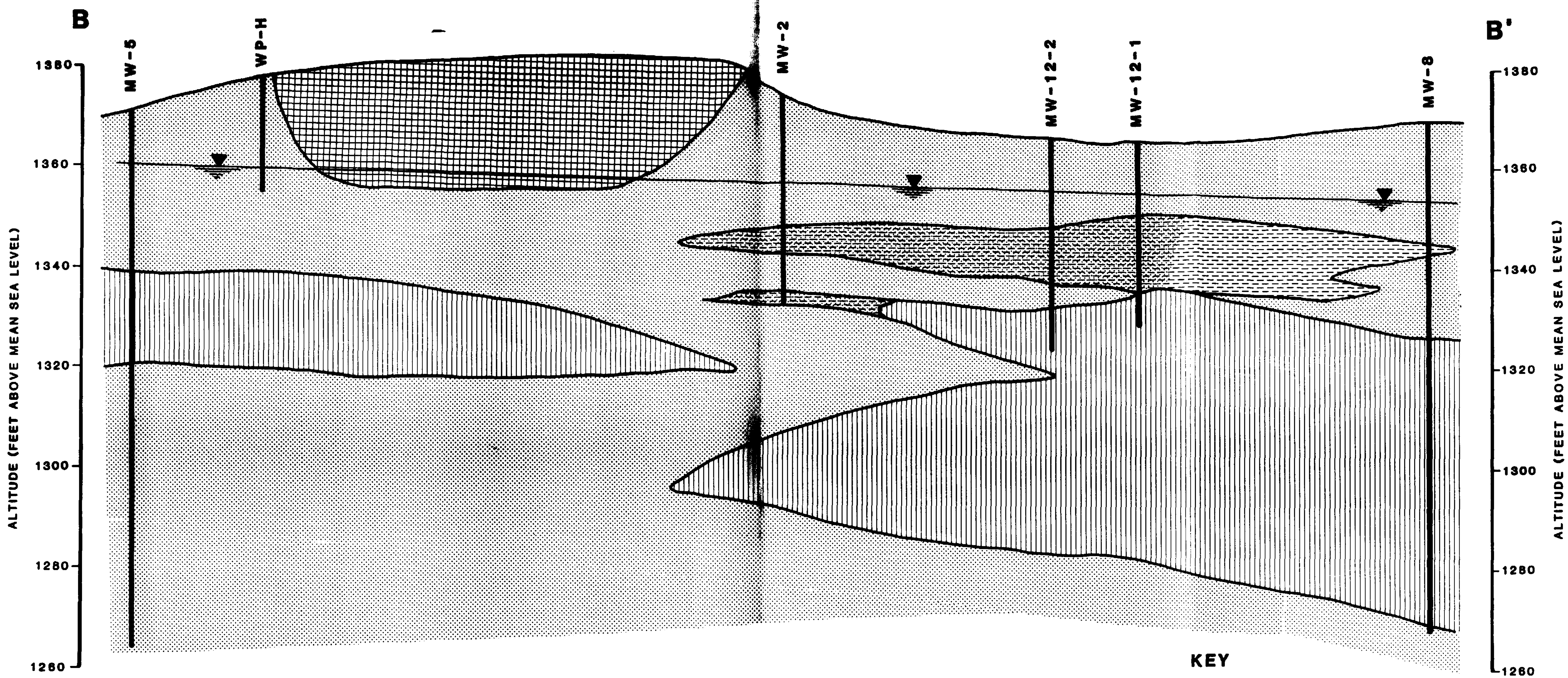
MALCOLM PIRNIE

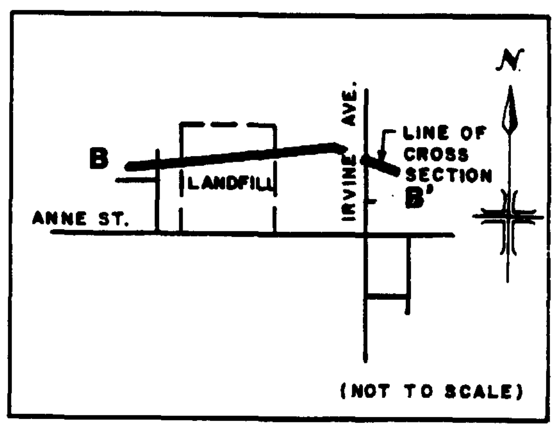
KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

GEOLOGIC CROSS - SECTION A - A'

MALCOLM PIRNIE, INC.

FIGURE 3-2





LOCATION MAP

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=250'
VERTICAL EXAGGERATION = 12.5 X

NOTES:

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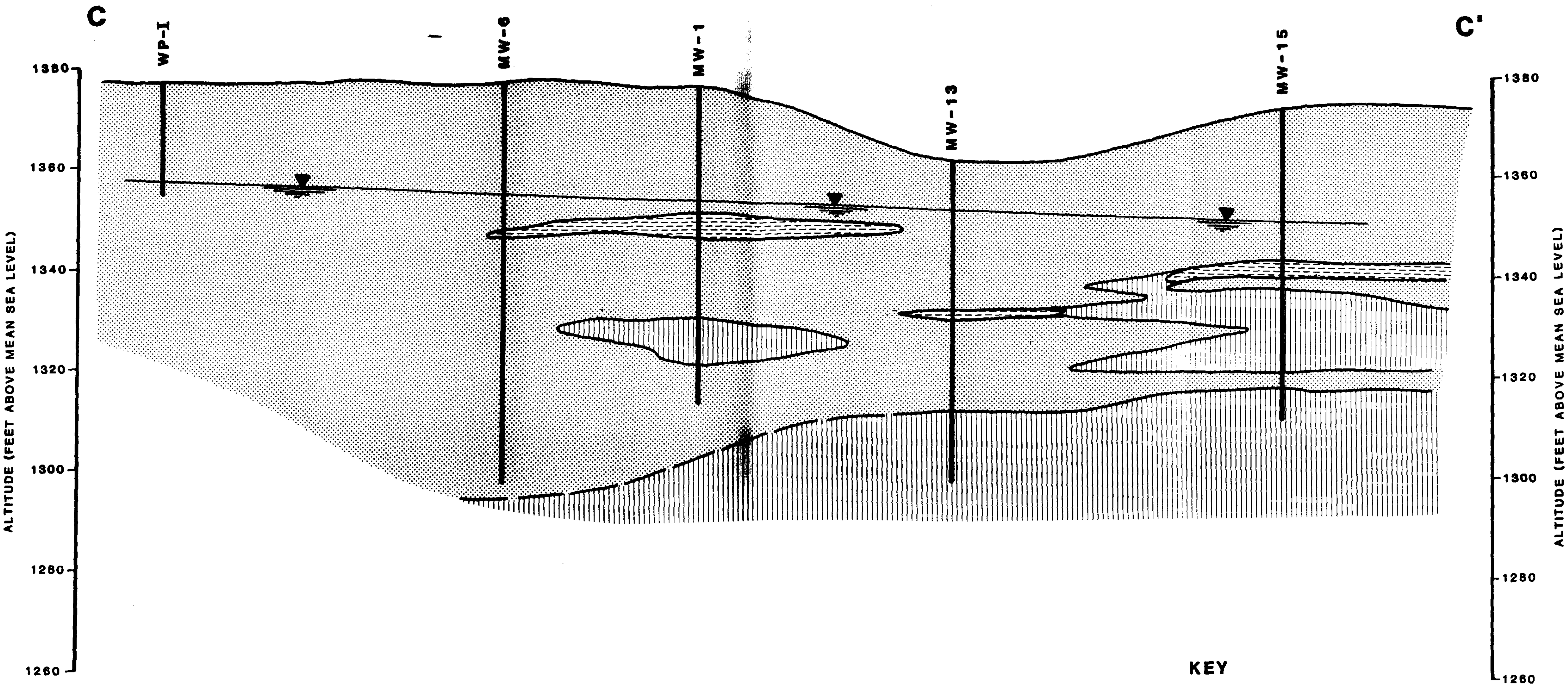
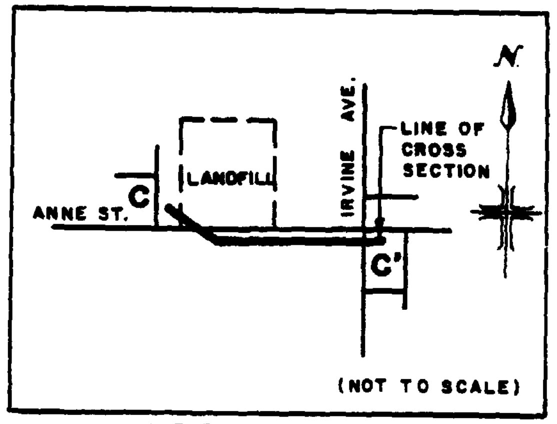
KEY

- SAND
- CLAY AND/OR SILT
- GRAVEL
- TILL (SAND, CLAY, GRAVEL)
- LANDFILL
- ▼ WATER TABLE ELEVATION (TAKEN FEB. 16-18, 1988)
- MW-1 MONITORING WELL NO.
- WP-A WELL POINT

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION MINNESOTA POLLUTION CONTROL AGENCY	GEOLOGIC CROSS - SECTION B - B'	MALCOLM PIRNIE, INC. FIGURE 3-3





LOCATION MAP

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=250'
VERTICAL EXAGGERATION = 12.5 X

NOTES:

1. THE LOCATION OF THE GEOLOGIC CROSS SECTION IS SHOWN ON THE LOCATION DETAIL MAP, FIGURE 3-1.
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5. SHAPE AND DIMENSIONS OF LANDFILL AS SHOWN MAY NOT REFLECT ACTUAL CONSTRUCTION.

KEY

SAND

CLAY AND/OR SILT

GRAVEL

TILL (SAND, CLAY, GRAVEL)

LANDFILL

▼ WATER TABLE ELEVATION (TAKEN FEB. 16-18, 1988)

MW-1 MONITORING WELL NO.

WP-A WELL POINT

MALCOLM PIRNIE

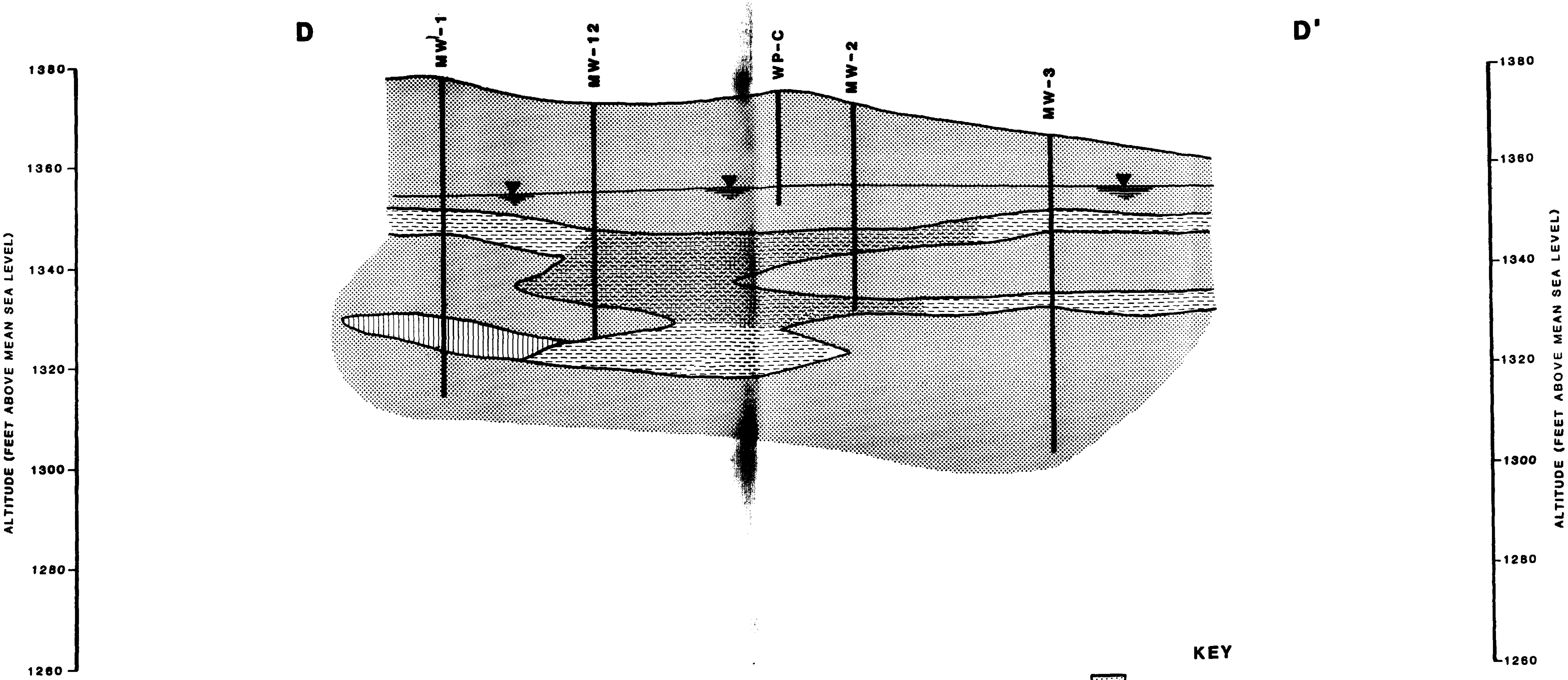
KUMMER LANDFILL REMEDIAL INVESTIGATION

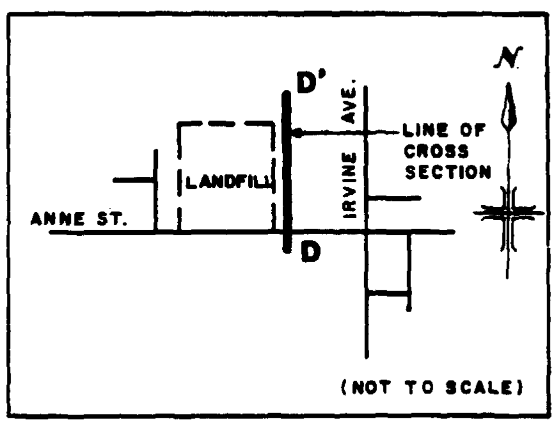
MINNESOTA POLLUTION CONTROL AGENCY

GEOLOGIC CROSS - SECTION C - C'

MALCOLM PIRNIE, INC.

FIGURE 3-4





LOCATION MAP

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=250'
VERTICAL EXAGGERATION = 12.5 X

NOTES:

1. THE LOCATION OF THE GEOLOGIC CROSS SECTION IS SHOWN ON THE LOCATION DETAIL MAP, FIGURE 3-1.
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KEY

- SAND
- CLAY AND/OR SILT
- GRAVEL
- TILL (SAND, CLAY, GRAVEL)
- LANDFILL
- ▼ WATER TABLE ELEVATION (TAKEN FEB. 16-18, 1988)
- MW-1 MONITORING WELL NO.
- WP-A WELL POINT

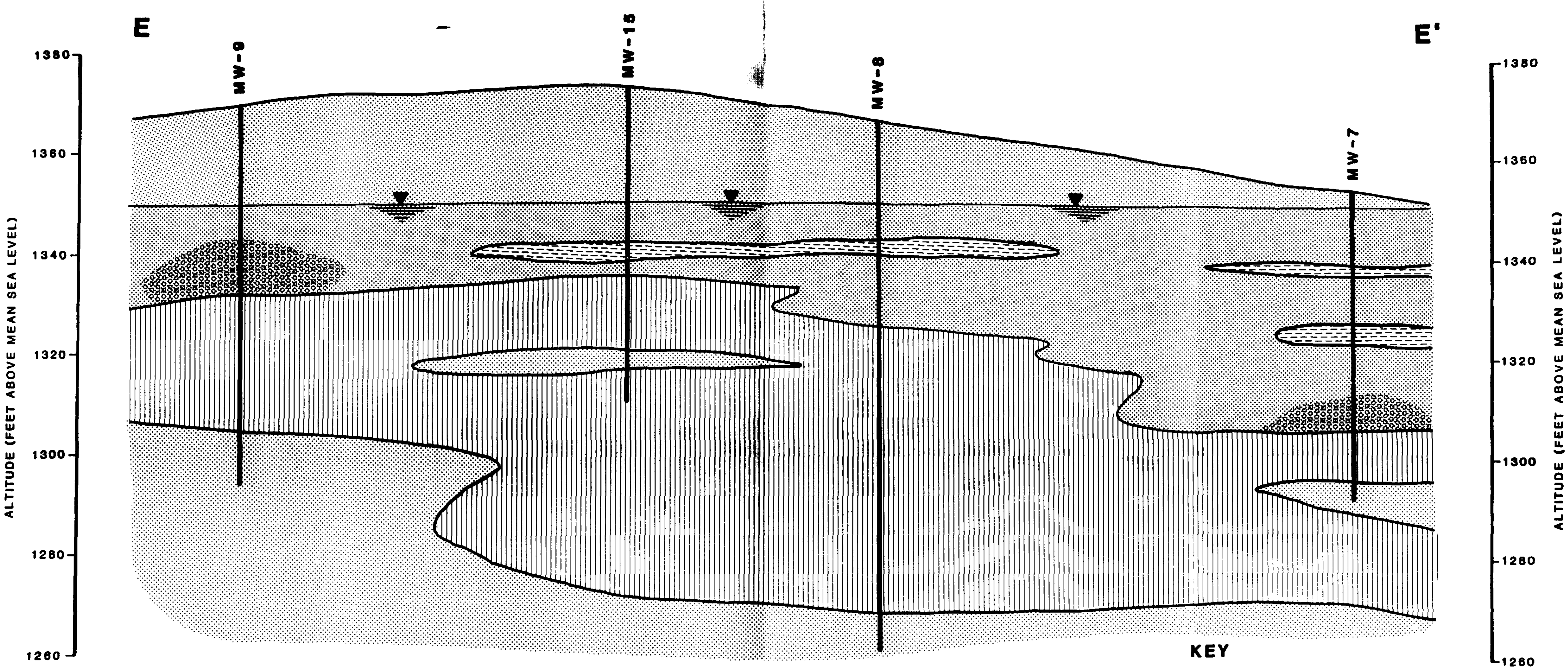
MALCOLM PIRNIE

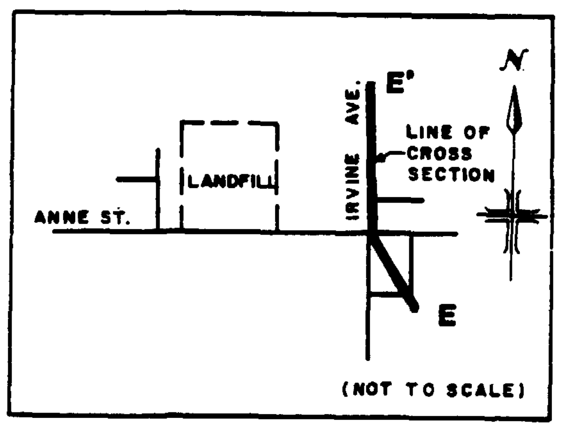
KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

GEOLOGIC CROSS - SECTION D - D'

MALCOLM PIRNIE, INC.

FIGURE 3-5





LOCATION MAP

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=250'
VERTICAL EXAGGERATION = 12.5 X

NOTES:

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KEY

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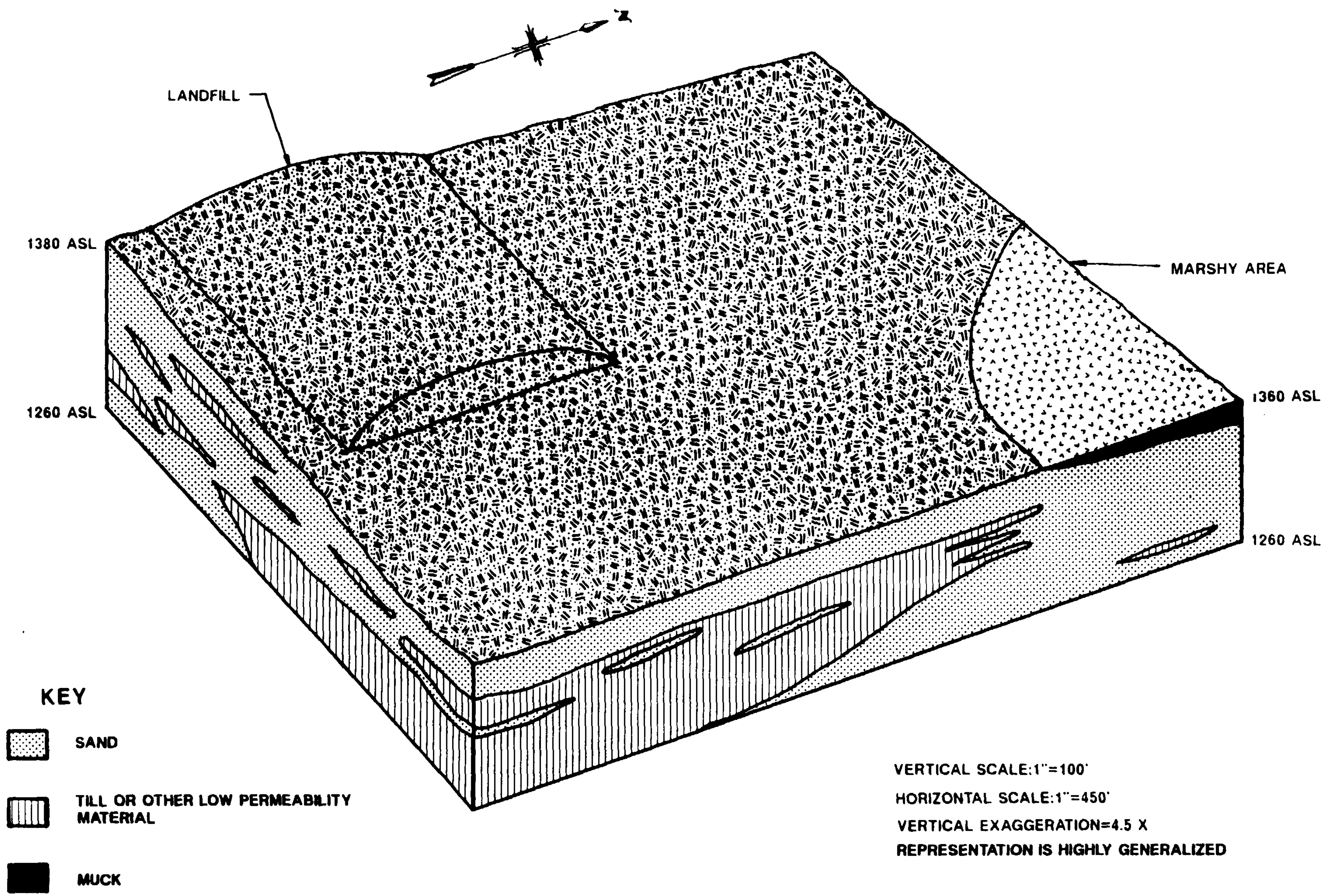
- GRAVEL
- TILL (SAND, CLAY, GRAVEL)
- LANDFILL
- ▼ WATER TABLE ELEVATION (TAKEN FEB. 16-18, 1988)
- MW-1 MONITORING WELL NO.
- WP-A WELL POINT

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION MINNESOTA POLLUTION CONTROL AGENCY	GEOLOGIC CROSS - SECTION E - E'	MALCOLM PIRNIE, INC. FIGURE 3-6



MALCOLM PIRNIE

KUMMER LANDFILL
REMEDIAL INVESTIGATION
BLOCK DIAGRAM

MALCOLM PIRNIE, INC.

FIGURE 3-7

they occur, are the shallow zone of the unconfined aquifer and are of moderate transmissivity. Ground water in this aquifer flows generally to the east, where it eventually discharges into Lake Bemidji. The direction of flow can be seen on the ground water altitude contour maps for the shallow zone of the unconfined aquifer presented on Figures 3-8 and 3-9. The hydraulic gradient (change in ground water altitude per unit distance) of this zone ranges from 0.0024 ft/ft to 0.0030 ft/ft.

Discontinuous clay lenses encountered at some locations within the study area do not appear to be confining units. A confining unit is less permeable than the formations surrounding it and restricts the amount of water transmitted between those formations. This creates a confined aquifer in the formation below the less-permeable unit. The hydraulic head in this aquifer is usually different from the water table. Wells screened above and below the clays at a specific location show little appreciable difference in hydraulic head levels. Well MW-7B does have a head level three feet higher than MW-7A, which is screened above MW-7B and separated from it by two clay layers. This relationship can be seen in the ground water altitudes presented in Table 3-4. These wells are located adjacent to a bog, however, and ground water in MW-7A is immediately below land surface while MW-7B is a flowing well. This kind of head relationship is common in an unconfined aquifer near a discharge zone.

The till, however, does appear to be acting locally as a confining unit or as an obstruction to flow retarding vertical and horizontal movement of ground water. Head relationships between wells screened in sands above and below the till differ by 0.5 to 1.0 feet, with a downward vertical gradient west of the landfill and an upward vertical gradient to the north and east. The direction of vertical gradient is determined by the relative head levels in wells screened at different altitudes in the aquifer. If the head level in the shallow wells is higher than that in deeper wells, flow in the aquifer will be from the water table surface downward. If the head levels are reversed, flow

TABLE 3-4

GROUND WATER ALTITUDES
KUMMER LANDFILL REMEDIAL INVESTIGATION

Well No.	Top of Casing	November 5, 1986		December 16-17, 1986		February 16-18, 1987		April 28-30, 1987	
		Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude
1A	1,379.65'	23.52'	1,356.13	23.69'	1,355.96	24.1'	1,355.55	-	-
1B	1,379.50'	23.48'	1,356.02	23.80'	1,355.70	24.1'	1,355.40	-	-
1C	1,379.65'	23.57'	1,356.08	23.83'	1,355.82	24.2'	1,355.45	-	-
2A	1,373.44'	16.73'	1,356.71	16.93'	1,356.51	17.35'	1,356.09	-	-
2B	1,373.39'	16.74'	1,356.65	16.96'	1,356.43	17.35'	1,356.04	-	-
3A	1,368.03'	11.49'	1,356.54	11.51'	1,356.52	12.1'	1,355.93	-	-
3B	1,367.58'	11.03'	1,356.55	11.30'	1,356.28	11.65'	1,355.93	-	-
3C	1,367.91'	10.83'	1,357.08	11.16'	1,356.75	11.5'	1,356.41	-	-
4A	1,368.14'	10.71'	1,357.43	11.04'	1,357.10	11.4'	1,356.74	-	-
5A	1,372.97'	13.25'	1,359.72	13.45'	1,359.52	13.95'	1,359.02	-	-
5B	1,373.32'	13.38'	1,359.94	13.81'	1,359.51	14.3	1,359.02	-	-
5C	1,372.94'	13.93'	1,359.01	14.26'	1,358.68	14.6'	1,358.34	-	-
6A	1,380.86'	23.65'	1,357.21	23.85'	1,357.01	24.3'	1,356.56	-	-
6B	1,380.72'	23.60'	1,357.12	23.79'	1,356.93	24.25'	1,356.47	-	-
7A	1,355.86'	4.10'	1,351.76	ND	ND	4.8'	1,351.06	4.7'	1,351.16
7B	1,355.96'	1.12'	1,354.84			1.4'	1,354.56	1.2'	1,354.76
8A	1,369.80'	17.40'	1,352.40	17.58'	1,352.22	18.0'	1,351.80	18.05'	1,351.75
8B	1,369.95'	17.80'	1,352.15	17.97'	1,351.98	18.4'	1,351.55	18.47'	1,351.48
8C	1,369.59'	15.83'	1,353.76	16.04'	1,353.55	16.3'	1,353.29	17.55'	1,352.04
9A	1,372.40'	21.73'	1,350.67	21.91'	1,350.49	22.3'	1,350.10	22.51'	1,349.89
9B	1,372.36'	21.41'	1,350.95	21.58'	1,350.78	22.0'	1,350.36	22.17'	1,350.19
9C	1,372.33'	20.94'	1,351.39	21.12'	1,351.21	21.5'	1,350.83	21.7'	1,350.63

TABLE 3-4

GROUND WATER ALTITUDES
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Well No.	Top of Casing	February 22-24, 1988 Depth to Water	February 22-24, 1988 Groundwater Altitude	March 22-24, 1988 Depth to Water	March 22-24, 1988 Groundwater Altitude
1A	1,379.65'	24.11'	1,355.54	24.28'	1,355.37
1B	1,379.50'	24.08'	1,355.42	24.28'	1,355.22
1C	1,379.65'	23.23'	1,356.42	24.31'	1,355.34
2A	1,373.44'	17.29'	1,356.15	17.06'	1,356.38
2B	1,373.39'	17.36'	1,356.03	17.39'	1,356.00
3A	1,368.03'	12.09'	1,355.94	11.98'	1,356.05
3B	1,367.58'	11.61'	1,355.97	11.58'	1,356.00
3C	1,367.91'	11.50'	1,356.41	11.52'	1,356.39
4A	1,368.14'	11.35'	1,356.79	11.22'	1,356.92
5A	1,372.97'	13.91'	1,359.06	14.04'	1,358.93
5B	1,373.32'	14.30'	1,359.02	14.46'	1,358.86
5C	1,372.94'	14.61'	1,358.33	14.80'	1,358.14
6A	1,380.86'	24.28'	1,356.58	24.44'	1,356.42
6B	1,380.72'	24.28'	1,356.44	24.41'	1,356.31
7A	1,355.86'	4.72'	1,351.14	4.10'	1,351.76
7B	1,355.96'	0.40'	1,355.56	1.99'	1,353.97
8A	1,369.80'	17.98'	1,351.82	18.05'	1,351.75
8B	1,369.95'	18.37'	1,351.58	18.44'	1,351.51
8C	1,369.59'	16.45'	1,353.14	16.57'	1,353.02
9A	1,372.40'	22.31'	1,350.09	22.47'	1,349.93
9B	1,372.36'	21.98'	1,350.38	22.15'	1,350.21
9C	1,372.33'	22.05'	1,350.28	21.67'	1,350.66

TABLE 3-4

GROUND WATER ALTITUDES
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Well No.	Top of Casing	February 22-24, 1988 Depth to Water	February 22-24, 1988 Groundwater Altitude	March 22-24, 1988 Depth to Water	March 22-24, 1988 Groundwater Altitude
10A	1,355.37	3.87'	1,351.50	3.94'	1,351.43
11A	1,361.93	8.10'	1,353.83	7.87'	1,354.06
11B	1,361.16	6.33'	1,354.83	6.53'	1,354.63
12B	1,376.92	21.16'	1,355.76	21.23'	1,355.69
P1	1,376.45	20.73'	1,355.72	20.83	1,355.62
P2	1,375.12	19.64'	1,355.48	19.72'	1,355.40
13A	1,367.35	12.53'	1,354.82	12.73'	1,354.62
13B	1,367.03	12.60'	1,354.43	12.76'	1,354.27
14A	1,379.06	24.30'	1,354.76	24.84'	1,354.22
15A	1,377.43	28.45'	1,348.98	25.39'	1,352.04
15B	1,377.48	25.68'	1,351.80	25.72'	1,351.76
15C	1,377.16	24.63'	1,352.53	24.57'	1,352.59

TABLE 3-4

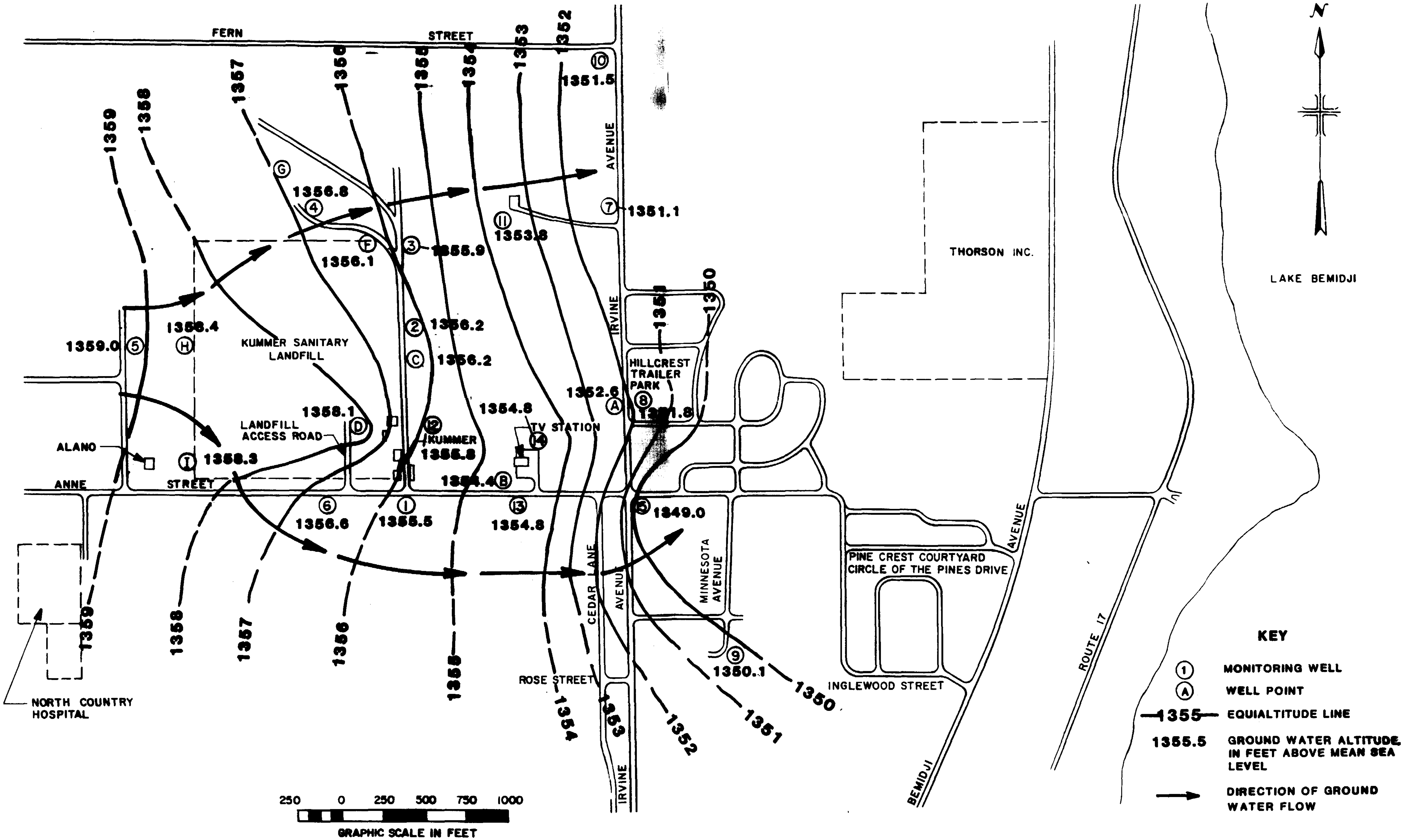
GROUND WATER ALTITUDES
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

		November 5, 1986		December 16-17, 1986		February 16-18, 1987		April 28-30, 1987	
Well No.	Top of Casing	Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude
A	1,373.02'	19.94'	1,353.08	20.07'	1,352.95	-	-	-	-
B	1,373.47'	18.45'	1,355.02	18.63'	1,354.84	-	-	-	-
C	1,376.40'	19.64'	1,356.76	19.81'	1,356.59	-	-	-	-
D	1,378.11'	21.08'	1,357.03	-	-	-	-	-	-
F	1,368.09'	11.33'	1,356.76	11.55'	1,356.54	-	-	-	-
G	1,368.19'	Dry	-	Dry	-	-	-	-	-
H	1,379.43'	20.23'	1,359.20	20.43'	1,359.00	-	-	-	-
I	1,378.91'	19.90'	1,359.01	20.14'	1,358.77	-	-	-	-

TABLE 3-4

GROUND WATER ALTITUDES
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

		February 22-24, 1988		March 22-24, 1986	
Well No.	Top of Casing	Depth to Water	Groundwater Altitude	Depth to Water	Groundwater Altitude
A	1,373.02'	20.42'	1,352.60	20.51'	1,352.51
B	1,373.47'	19.04'	1,354.43	19.23'	1,354.24
C	1,376.40'	20.21'	1,356.19	20.34'	1,356.06
D	1,378.11'	20.06'	1,358.05	20.31	1,357.80
F	1,368.09'	11.95'	1,356.14	11.84'	1,356.25
G	1,368.19'	Dry	-	11.19'	1,357.00
H	1,379.43'	20.99'	1,358.44	21.16'	1,358.27
I	1,378.91'	20.62'	1,358.29	20.83'	1,358.08



Base map from orthophoto flown in 1985.
Wells surveyed in 1986, 1988.

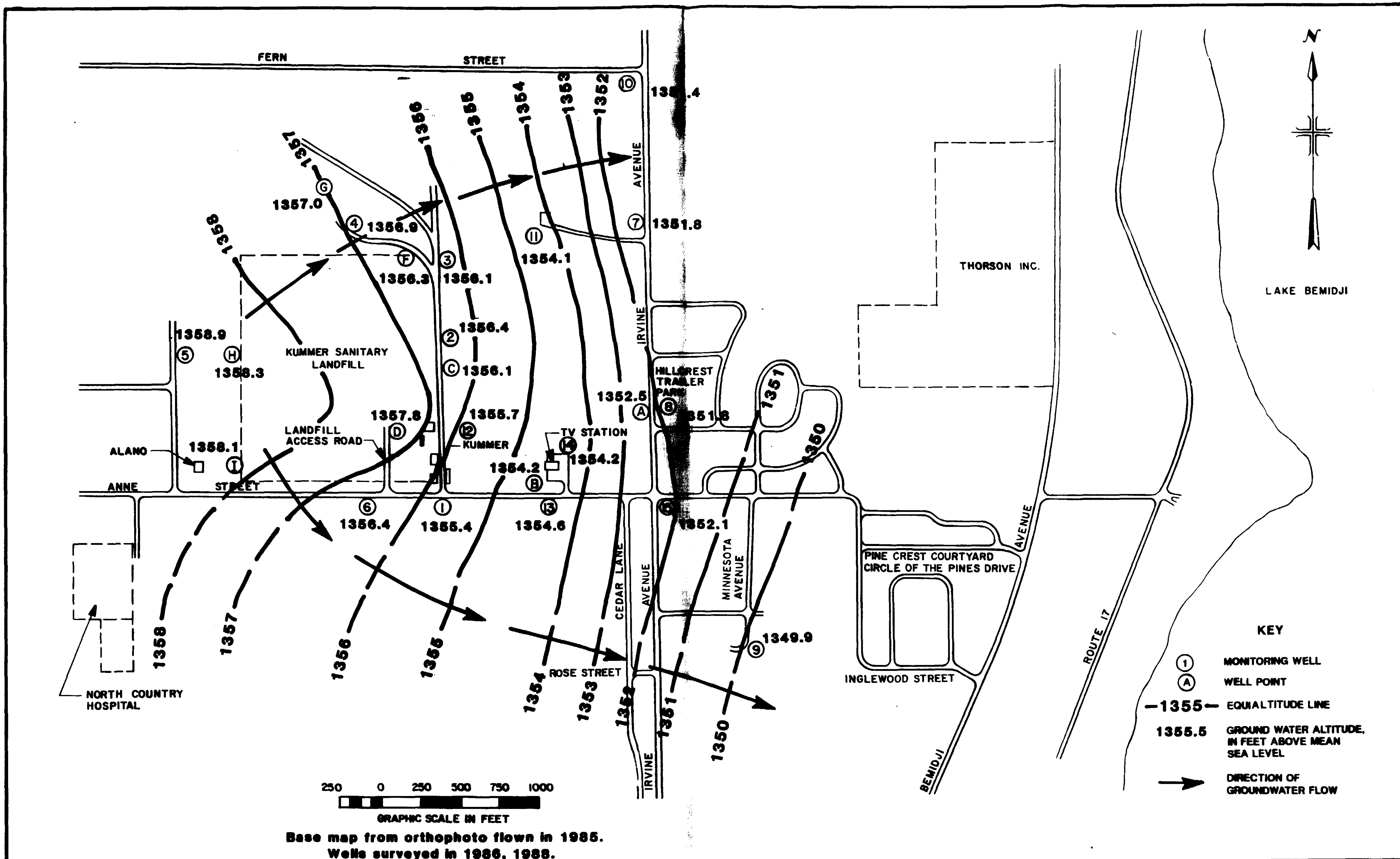
MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

GROUND WATER ALTITUDE CONTOUR MAP
WATER TABLE AQUIFER (FEB. 16-18, 1988)

MALCOLM PIRNIE, INC.

FIGURE 3-8



MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION

MINNESOTA POLLUTION CONTROL AGENCY

GROUND WATER ALTITUDE CONTOUR MAP

WATER TABLE AQUIFER (MAR. 22-24, 1988)

MALCOLM PIRNIE, INC.

FIGURE 3-9

direction will be in the opposite direction. The directions of vertical gradient are illustrated in the hydrogeologic cross-section presented in Figure 3-10.

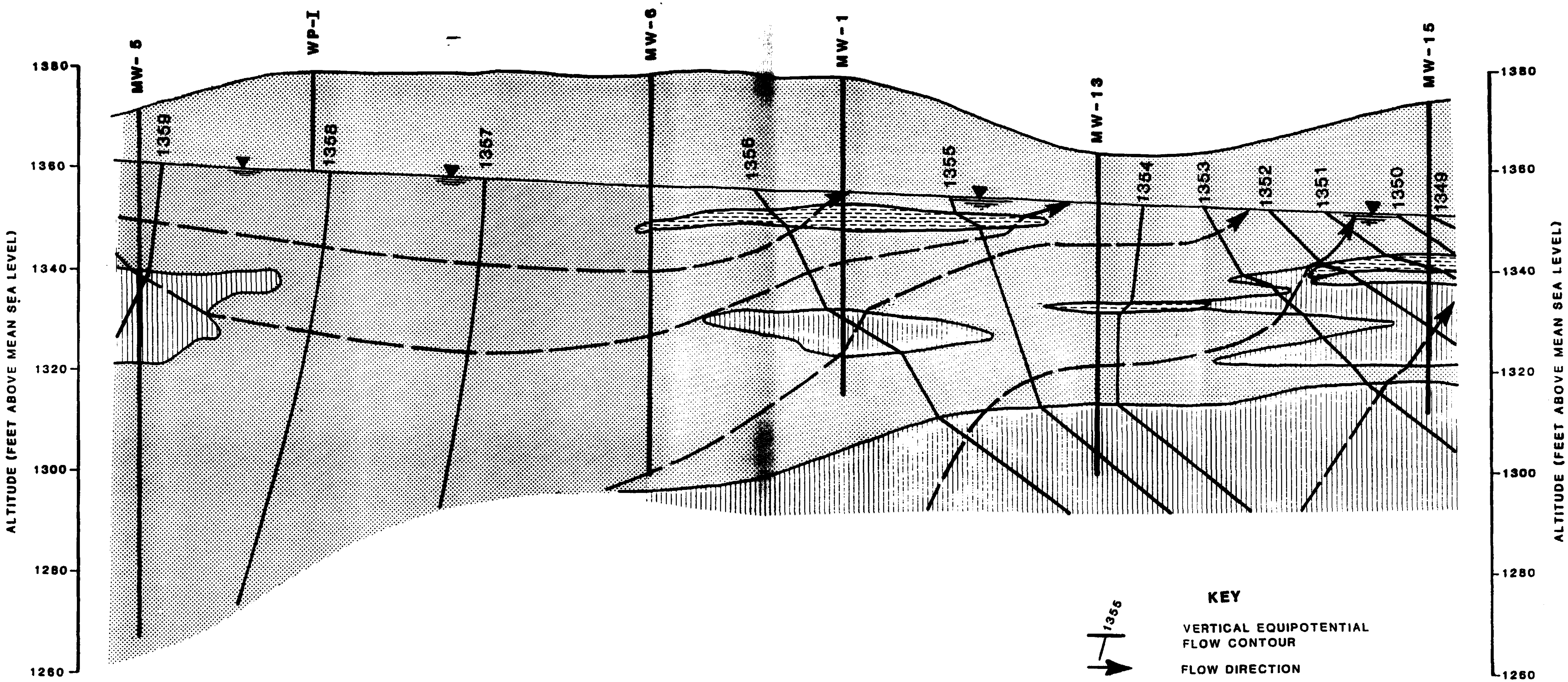
The change in direction of the vertical gradient on either side of the landfill is probably caused by a difference in the horizontal gradients of different zones in the aquifer. Though the general direction of flow in the deeper zone of the aquifer is also towards Lake Bemidji, its gradient is between 0.0018 and 0.0019, slightly shallower than that of the shallow zone. These ground water altitudes are shown in Table 3-4 and the direction of flow is presented in Figures 3-11 and 3-12. The piezometric surface of the deeper zone of the aquifer is slightly lower than the shallow zone west of the landfill, whereas in the area along the eastern border of the fill the altitudes of water levels in the two aquifer zones become the same. East of that area, the piezometric surface of the deeper zone of the aquifer becomes higher than the shallow zone.

3.5 AQUIFER TESTS

During the supplemental remedial investigation a six-inch "B" depth monitoring well was installed so that a pumping test could be conducted. It was planned originally that this well would be installed in the open field to the north of the TV station. Test borings were drilled and showed the area to be underlain by low permeability silts, clay and/or till from about 25 to 45 feet below ground level. The locations of test borings 12-1 and 12-2 are shown on Figure 1-7. The pumping well location was then moved to near the eastern edge of the Kummer property between monitoring wells MW-1 and MW-2. This location was chosen for MW-12B because:

1. According to available geologic information this area was representative of general site subsurface conditions.

2. It is in an area where a ground water interception or leachate collection system might be considered for the FS.

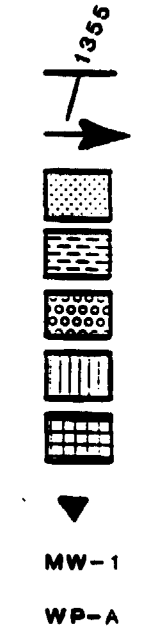


VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=250'
VERTICAL EXAGGERATION = 12.5 X

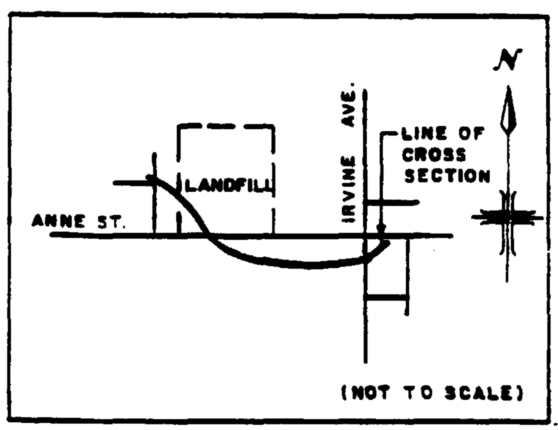
NOTES:

1. THE LOCATION OF THE GEOLOGIC CROSS SECTION IS SHOWN ON THE LOCATION DETAIL MAP, FIGURE 3-1
2. THE STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN WIDELY SPACED BORINGS. ACTUAL FIELD CONDITIONS MAY VARY FROM THOSE SHOWN
3. GENERALIZED SOIL DESCRIPTIONS ARE SHOWN BETWEEN STRATUM LINES. FOR MORE DETAILED DESCRIPTIONS REFER TO ACTUAL WELL AND BORING LOGS.
4. GROUND WATER LEVELS WILL FLUCTUATE. FLUCTUATIONS IN LEVELS WILL RESULT FROM VARIATIONS IN RAINFALL, TEMPERATURE, SEASON AND OTHER FACTORS.
5. SHAPE AND DIMENSIONS OF LANDFILL AS SHOWN MAY NOT REFLECT ACTUAL CONSTRUCTION.

KEY



VERTICAL EQUIPOTENTIAL FLOW CONTOUR
FLOW DIRECTION
SAND
CLAY AND/OR SILT
GRAVEL
TILL (SAND, CLAY, GRAVEL)
LANDFILL
WATER TABLE ELEVATION (TAKEN FEB. 16-18, 1988)
MONITORING WELL NO.
WELL POINT



LOCATION MAP

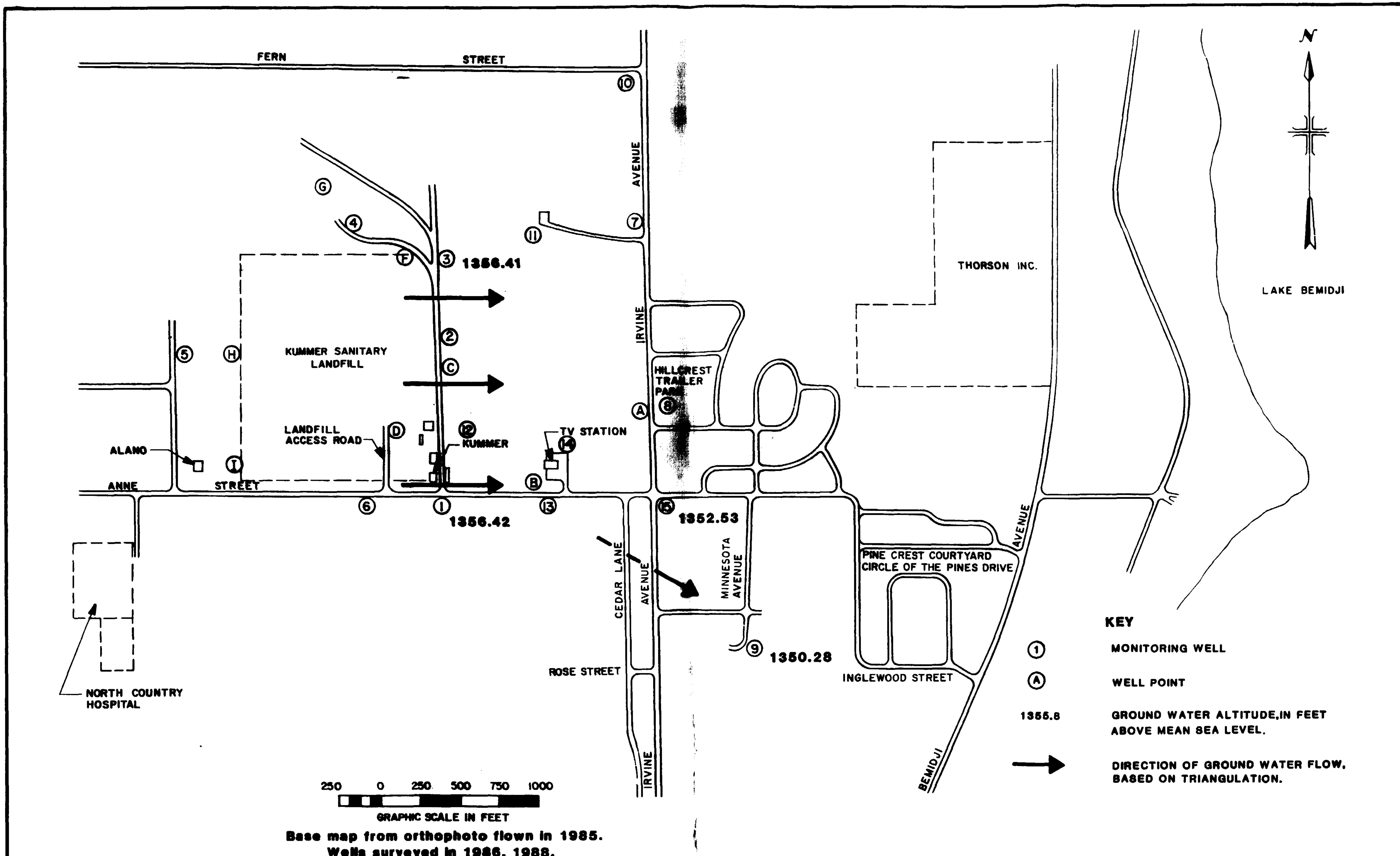
MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

HYDROGEOLOGIC CROSS - SECTION
ALONG GROUND WATER FLOW LINE

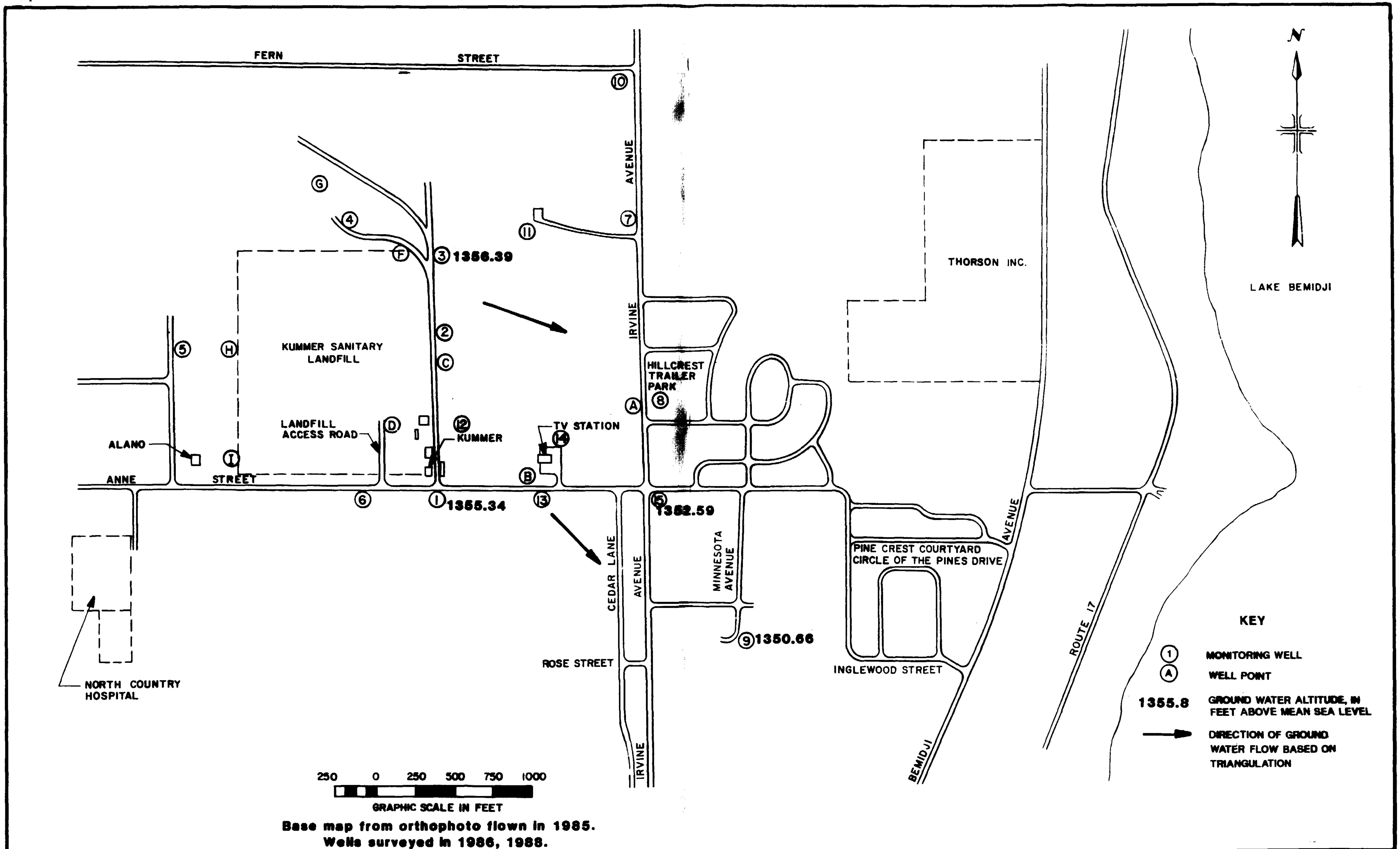
MALCOLM PIRNIE, INC.

FIGURE 3-10



Base map from orthophoto flown in 1985.
Wells surveyed in 1986, 1988.

MALCOLM PIRNIE	KUMMER LANDFILL REMEDIAL INVESTIGATION MINNESOTA POLLUTION CONTROL AGENCY	GROUND WATER ALTITUDE FLOW MAP DEEPER ZONE OF WATER TABLE AQUIFER (FEB.16 - FEB.18, 1988)	MALCOLM PIRNIE, INC. FIGURE 3-11



MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

GROUND WATER ALTITUDE FLOW MAP
DEEPER ZONE OF WATER TABLE AQUIFER (MAR. 22-24, 1988)

MALCOLM PIRNIE, INC.

FIGURE 3-12

After completion and development of the well it was discovered that the upper outwash sands in that area are much less productive than was estimated originally. Based on discharge observed during development, it was determined that sustained production should not exceed 12 gpm. A discharge of 10 gpm was chosen for the pumping test which was conducted on February 23 and 24, 1988.

The aquifer was pumped for 24 hours during which time regular water level measurements were made in the pumping well and two piezometers located 50 and 150 feet away from the pumping well. These piezometers (P-1 and P-2) are located on Figure 1-7. Other, more distant wells were also measured to monitor any changes in background conditions during the test.

Water was removed from the well with a 3/4-horsepower submersible pump set at 22 feet below the water table surface. Water was discharged approximately 700 feet away from the well through a flexible PVC tube. Water levels in the piezometers were measured and recorded with pressure tranducers and a Hermit data logger. Other wells were measured with an M-scope and were recorded by hand. At the end of the pumping test the pump was shut off and water levels were recorded during well recovery.

Slug tests were conducted on several of the B wells and one C well to estimate variations in hydraulic conductivity in the area. The tests were conducted by introducing a volume of distilled water into the well and measuring the loss of head or the rate at which water was being accepted by the aquifer. Water levels were measured and recorded with a pressure transducer and Hermit data logger, respectively. Slug tests were not conducted on the A wells because these wells are screened above the potentiometric surface.

Data from the pumping and recovery test and slug tests were analyzed using standard methods. These are described in Section 3.6.1 and the results are presented in Section 3.6.2.

3.6 AQUIFER ANALYSES

3.6.1 Analytical Methods

Hydraulic conductivity and transmissivity values have been estimated for the upper 30 feet of saturated water table aquifer in the vicinity of the landfill. These values were calculated using conventional analytical methods based on the results of the pumping test conducted on MW-12B and slug tests conducted on several monitoring wells.

Distance-drawdown calculations for the pumping well and piezometers were made using Neuman's, 1975 method as presented by Walton, 1987. This model assumes that the wells fully penetrate a uniformly porous water table aquifer underlain by an aquiclude. Other conditions for the model require that the aquifer is homogenous, stratified, of constant thickness and infinite in areal extent. Most of these conditions were met at the scale of the pumping test.

The Jacob straight-line method as presented by Fetter, 1980, was used to analyze drawdown and recovery data from the pumping well. The Jacob method, an approximation of the Theis non-equilibrium solution, is based on assumptions similar to Neuman's.

Analyses of slug test data by Hvorslev's, 1951 time-lag method also assume a homogenous, unstratified, infinite aquifer. This method is based on empirical formulas which state that the rate of inflow of water to a particular formation is proportional at any time to hydraulic conductivity and the unrecovered head difference in the piezometer.

3.6.2 Analytical Results

Hydraulic conductivity values for the upper portion of the aquifer are presented in Table 3-5. All of the values for MW-12B are based on results of the pumping test. Data obtained from the piezometers used to monitor the test were limited in value, as very little response to the pumping was observed.

The range of hydraulic conductivities for MW-12B is most likely the result of changing aquifer conditions from the beginning to the end of the test. The most important change would be a reduction of aquifer thickness caused by the removal of water from storage during continuous pumping. This change would result

TABLE 3-5

HYDRAULIC CONDUCTIVITY VALUES
KUMMER LANDFILL REMEDIAL INVESTIGATION

Monitoring Well	K (ft/day)	Method	Comment
MW-12B	14	Neuman,1975	Distance - Drawdown after 1.3 hours
MW-12B	6	Neuman,1975	Distance - Drawdown after 24 hours
MW-12B	12	Jacob	Early portion of pumping test
MW-12B	4	Jacob	Late portion of pumping test
MW-12B	2	Jacob	Early recovery data
MW-12B	12	Jacob	Late recovery data
MW-2B	60	Hvorslev	Slug injection (2 gallons distilled water)
MW-3B	45	Hvorslev	Slug injection (2 gallons distilled water)
MW-5B	30	Hvorslev	Slug injection (1.5 gallons distilled water)
MW-6B	30	Hvorslev	Slug injection (2 gallons distilled water)
MW-8B	30	Hvorslev	Slug injection (2 gallons distilled water)
MW-15B	3	Hvorslev	Slug injection (2.5 gallons distilled water)
MW-15C	0.10	Hvorslev	Slug injection (3 gallons distilled water)

in lower calculated values of aquifer transmissivity and hydraulic conductivity. Values based on the early data are most representative of true aquifer conditions at the particular location, however, if a dewatering or other ground water withdrawal system is installed as part of the landfill remediation, the change in transmissivity with time will have to be taken into account.

The remaining values of hydraulic conductivity listed on Table 3-5 are based on the results of slug injection tests. These values are generally higher than those based on the pumping test data. However, these differences should be considered with caution because slug tests generally impact that part of the aquifer which is immediately adjacent to the well screen. Therefore, a sand or gravel pack, if present, will affect the results of the tests, usually by indicating higher values of hydraulic conductivity than are actually present.

The results of slug tests conducted on MW-2B, MW-3B, MW-5B, MW-6B and MW-8B are fairly consistent and are interpreted here to represent the general uniformity of the outwash deposits in the upper 50 feet of aquifer. This uniformity is substantiated by well construction data and drilling logs presented in Appendices D and E. Monitoring wells 15B and 15C were completed in zones of fine to very fine sand and therefore have lower hydraulic conductivities than the outwash sands.

3.6.3 Ground Water Velocities

For the purposes of estimated ground water velocities a hydraulic conductivity (K) of 10 to 20 feet/day is used for the upper portion of the aquifer. A hydraulic gradient (I), based on the most recent water level measurements in monitoring wells at the site, is approximately 0.003 ft/ft. In some small areas the gradient is as steep as 0.012 ft/ft. Using the Darcy equation (V=KI), discharge velocities for the study area are estimated to range from 0.03 ft/day to 0.24 ft/day.

These velocities are low and indicate that contaminated ground water should not have migrated from the landfill to Lake Bemidji, nor much beyond about 1300 feet downgradient of the landfill (assuming a velocity of 0.24 ft/day and 15 years of migration time). Water quality analyses for private and monitoring wells beyond 1300 feet downgradient of the landfill indicate that contaminants are migrating at higher rates. This discrepancy may stem from one or a combination of reasons including:

1. During snow melt or precipitation events, more recharge will infiltrate the landfill than surrounding areas due to the greater permeability of the landfill materials. This may contribute to mounding of the water table beneath the fill, temporarily increasing the hydraulic gradient and causing an increase in the velocities of ground water leaving the landfill.

2. Undetected "channels" of higher hydraulic conductivity may be present resulting in preferred pathways for contaminant migration.

3. There may be other sources of contamination between the landfill and Lake Bemidji. (The preliminary investigation of site history does not support this.)

4. The pumping and slug test analyses are in error. (The results, as presented, have been confirmed by using different methods to analyze the data.)

5. Analytical results of water quality sampling are in error. (Sampling results have been confirmed through repeated sampling of individual wells.)

The first reason presented above suggests that slugs of contaminated water are moving from the landfill and through the area towards Lake Bemidji. These slugs are introduced into the ground water system and accelerated during periods of recharge. The second reason recognizes the complexity of glacially deposited sediments. Results of the soil boring programs at the site illustrate the high degree of variability of sediment types over a relatively small area. The density of soil borings is not great enough to reveal the nature or extent of a high permeability network.

It is most likely that a combination of the first and second reasons has resulted in the migration of contaminants farther from the landfill than is predicted by aquifer analysis. It is possible that additional error is introduced by the inherant inaccuracies of the graphical methods used to estimate hydraulic conductivities.

3.7 EXISTING RESIDENTIAL WELL DATA BASE

Ground water samples were obtained from a total of 14 different residential wells in Rounds 2 and 3. The selected residences are listed in Table 3-6 and are located approximately on Figure 3-13. The approximate depths of the wells are also given in that table. All the residential wells sampled are located east of the landfill with most located to the southeast.

Sampling and analyses of the residential wells were conducted so that ground water quality in the residential area could be characterized and to, possibly, link any ground water contamination there to any releases detected from the landfill. The residences were chosen based on their location and the amount of information available regarding their well depths. All are considered downgradient of the landfill and have been sampled previously by the MPCA. The analytical procedure originally performed on the sampled wells was Minnesota Department of Health (MDH) Method 465B.

3.8 GROUND WATER QUALITY

3.8.1 Ground Water Monitoring Program

Ground water monitoring prior to commencement of the remedial investigation in September, 1986 was conducted primarily by MPCA with analyses by MDH and to a lesser extent by Mr. Kummer. Results obtained during that time are discussed in Section 1.4 of this report. This section will discuss the ground water monitoring program included as part of this remedial investigation.

TABLE 3-6

RESIDENTIAL WELLS SAMPLED DURING RI
KUMMER LANDFILL REMEDIAL INVESTIGATION

ADDRESS	OWNER	DATE SAMPLED (ROUND)	APPROXIMATE DEPTH OF WELL (ft.)
NON-RESPONSIVE [redacted]	[redacted]	Feb. 19, 1987 (2)	42
[redacted]	[redacted]	Feb. 18, 1987 (2)	100
[redacted]	[redacted]	Feb. 18, 1987 (2)	23
[redacted]	[redacted]	April 29, 1987 (3)	
[redacted]	[redacted]	Feb. 18, 1987 (2)	21-22
[redacted]	[redacted]	Feb. 18, 1987 (2)	30
[redacted]	[redacted]	April 29, 1987 (3)	37
[redacted]	[redacted]	April 29, 1987 (3)	37
[redacted]	[redacted]	April 28, 1987 (3)	25-30
[redacted]	[redacted]	April 29, 1987 (3)	LT 20
[redacted]	[redacted]	April 29, 1987 (3)	Shallow
[redacted]	[redacted]	April 29, 1987 (3)	Shallow
[redacted]	[redacted]	April 29, 1987 (3)	24-28
[redacted]	[redacted]	April 30, 1987 (3)	35
[redacted]	[redacted]	April 30, 1987 (3)	65

LT = Less than

NON-RESPONSIVE

[redacted]

MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

LOCATIONS OF SAMPLED RESIDENTIAL WELLS
DURING ROUND 2 AND ROUND 3

MALCOLM PIRNIE, INC.

FIGURE 3-13

This program is divided into two parts. The first, or initial monitoring program, was conducted from December, 1986 to July 13, 1987 and is composed of three rounds of sampling and associated analyses. The initial program was conducted in accordance with Section 6.6, Sampling of the April, 1986 RI/FS Work Plan. The second monitoring program was included as a supplemental remedial investigation activity and was started on February 16, 1988. This sampling program is not yet completed. The second monitoring program was performed in accordance with Work Order Amendment No. 7 dated December 29, 1987. Specific dates for component parts of each of the monitoring programs are as follows:

Initial Sampling Program	Date(s)
Round 1	December 16 and 17, 1986
Round 2	February 18 and 19, 1987
Round 3	April 29 and 30, 1987
Second Monitoring Program	
Round 4	February 16, 17 and 18, 1988
Round 5	March 22, 23, and 24, 1988
Round 6	To Be Completed

Round 1 of the initial ground water monitoring program was conducted on December 16 and 17, 1986. Samples from the fourteen monitoring wells in Clusters 1 through 6 were obtained and submitted to CompuChem Laboratories, Inc. and to PACE Laboratories, Inc. for analyses of hazardous substance list (HSL) parameters and water quality parameters (WQP), respectively. Chemical analyses of all samples is discussed in the next section. It was the intent of Round 1 sampling to determine the presence and levels of any contaminants in ground water around the perimeter of the landfill. Background characterization of ground water quality was achieved by analyzing samples from MW-5A,B, and C monitoring wells located upgradient of the landfill.

Following a review and evaluation of Round 1 analytical results, a Round 2 Sampling and Analytical Plan was prepared detailing Round 2 sampling activities. These included collection of samples from all Cluster 1 through 6 monitoring wells for volatile fraction HSL analysis, samples from MW-1A and 2A for semi-volatile fraction HSL analysis, and samples from the eight monitoring wells in Clusters 7, 8, and 9 for full HSL and WQP analyses. Samples from five residential potable wells were collected for full HSL and WQP analyses.

A Round 3 Sampling and Analytical Plan was prepared based upon an evaluation of Round 2 results. Round 3 included obtaining samples from all Cluster 7, 8, and 9 wells for volatile fraction HSL analyses, samples from ten residential potable wells for volatile fraction HSL analyses, and sediments from three locations (pond, south ditch, and west ditch) around the perimeter of the landfill for full HSL analyses.

The second ground water monitoring program commenced on February 16, 1988, and includes Rounds 4, 5 and 6. The Sampling and Analytical Plan for this second monitoring program was based on the earlier rounds and Supplemental Remedial Investigation work plan. Round 4 included sampling of all old and new monitoring wells for volatile fraction HSL analyses. Samples from monitoring wells in Clusters 5 and 7 through 15 were collected during Round 5 and were also analyzed for volatile fraction HSL. A Round 6 Sampling and Analytical Plan will be prepared based on the results of earlier sampling rounds.

3.8.2 <u>Ground water Analyses</u>

All monitoring wells in Clusters 1 through 9 were sampled during Rounds 1 and 2, wells in Clusters 7, 8 and 9 during Rounds 2 and 3, and wells in Clusters 1 through 15 during Round 4. Results of Round 5 have not been received and Round 6 has yet to be completed. Analyses, method references and method detection limits for HSL analyses are given in Table 3-7. Results for organic HSL analyses are given in Table 3-8 for monitoring wells and Table 3-9 for residential wells. Table 3-10 contains analy-

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION

Parameter	Method Reference[1] Water/Soil	Method Detection Limit[2] Water/Soil	Contract Required Quantitation Limit (CRQL)[3] Water/Soil
HSL Volatile Organics	EPA 624/SW 8240	10µg/L, 10µg/kg	10µg/L, 10µg/kg
Acetone		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Benzene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Bromoform		5µg/L, 5µg/kg	5µg/L, 5µg/kg
2-Butanone		10µg/L, 10µg/kg	10µg/L, 10µg/kg
Carbon tetrachloride		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Carbon disulfide		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Chlorobenzene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Chlorodibromomethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Chloroethane		10µg/L, 10µg/kg	10µg/L, 10µg/kg
2-Chloroethyl vinyl ether		10µg/L, 10µg/kg	10µg/L, 10µg/kg
Chloroform		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Dichlorobromomethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
1,1-Dichloroethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
1,2-Dichloroethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
1,1-Dichloroethylene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
1,2-Dichloropropane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
cis-1,3-Dichloropropylene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
trans-1,3-Dichloropropylene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
2-Hexanone		10µg/L, 5µg/kg	10µg/L, 10µg/kg
Ethylbenzene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Methyl bromide		10µg/L, 10µg/kg	10µg/L, 10µg/kg
Methyl chloride		10µg/L, 10µg/kg	10µg/L, 10µg/kg
Methylene chloride		5µg/L, 5µg/kg	5µg/L, 5µg/kg
4-Methyl-2-pentanone		10µg/L, 10µg/kg	10µg/L, 10µg/kg
1,1,2,2-Tetrachloroethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Styrene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Tetrachloroethylene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Toluene		5µg/L, 5µg/kg	5µg/L, 5µg/kg

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Method Reference[1] Water/Soil	Method Detection[2] Limit Water/Soil	Contract Required Quantitation Limit (CRQL)[3] Water/Soil
HSL Volatile Organics	EPA 624/SW 8240	10µg/L, 10µg/kg	10µg/L, 10µg/kg
1,2-trans-Dichloroethylene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
1,1,1-Trichloroethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
1,1,2-Trichloroethane		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Trichloroethylene		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Vinyl acetate		10µg/L, 10µg/kg	10µg/L, 10µg/kg
Vinyl chloride		10µg/L, 10µg/kg	10µg/L, 10µg/kg
Xylene, total		5µg/L, 5µg/kg	5µg/L, 5µg/kg
Priority Pollutant Metals and Cyanide			
Metals Digestion	SW 3005/3010/3020/3050		
Aluminum	EPA 200.7/SW 6010	100µg/L, 10,000µg/kg	200µg/L, nd
Antimony	EPA 200.7/SW 6010	50µg/L, 5,000µg/kg	60µg/L, nd
Arsenic	EPA 206.2/SW 7060	10µg/L, 1,000µg/kg	10µg/L, nd
Barium	EPA 200.7/SW 6010	100µg/L, 10,000µg/kg	200µg/L, nd
Beryllium	EPA 200.7/SW 6010	5µg/L, 500µg/kg	5µg/L, nd
Cadmium	EPA 200.7/SW 6010	5µg/L, 500µg/kg	5µg/L, nd
Calcium	EPA 215.1/SW 7140	10µg/L, 1,000µg/kg	5,000µg/L, nd
Chromium	EPA 200.7/SW 6010	10µg/L, 1,000µg/kg	10µg/L, nd
Cobalt	EPA 200.7/SW 6010	30µg/L, 3,000µg/kg	50µg/L, nd
Copper	EPA 200.7/SW 6010	20µg/L, 2,000µg/kg	25µg/L, nd
Iron	EPA 200.7/SW 6010	20µg/L, 2,000µg/kg	100µg/L, nd
Lead	EPA 239.2/SW 7421	5µg/L, 500µg/kg	5µg/L, nd
Magnesium	EPA 242.1/SW 7450	5µg/L, 500µg/kg	5,000µg/L, nd
Manganese	EPA 200.7/SW 6010	10µg/L, 1,000µg/kg	15µg/L, nd
Mercury	EPA 245.1/SW 7470, 7471	0.2µg/L, 100µg/kg	0.2µg/L, nd

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Method Reference[1] Water/Soil	Method Detection [2] Limit Water/Soil	Contract Required Quantitation Limit (CRQL)[3] Water/Soil
Nickel	EPA 200.7/SW 6010	30μg/L, 3,000μg/kg	40μg/l, nd
Potassium	EPA 258.1/SW 7610	50μg/L, 5,000μg/kg	5,000μg/L, nd
Selenium	EPA 270.2/SW 7740	5μg/L, 500μg/kg	5μg/L, nd
Silver	EPA 200.7/SW 6010	10μg/L, nd	10μg/L, nd
Sodium	EPA 273.1/SW 7770	1000μg/L, nd	5,000μg/L, nd
Thallium	EPA 279.2/SW 7841	10μg/L, 1,000μg/kg	10μg/L, nd
Vanadium	EPA 200.7/SW 6010	50μg/L, nd	50μg/L, nd
Zinc	EPA 200.7/SW 6010	10μg/L, 1,000μg/kg	20μg/L, nd
Cyanide	EPA 335.2/SW 9010	10μg/L, nd	10μg/L, nd
Priority Pollutant Base Neutral Extractables	EPA 625/SW 3520/3550/8270		
Acenaphthene		1.9μg/L, nd	10μg/L, 330μg/kg
Acenaphthylene		3.5μg/L, nd	10μg/L, 330μg/kg
Anthracene		1.9μg/L, nd	10μg/L, 330μg/kg
Benzidine		44μg/L, nd	50μg/L, 1600μg/kg
Benzo (a) Anthracene		7.8μg/L, nd	10μg/L, 330μg/kg
Benzo (a) Pyrene		2.5μg/L, nd	10μg/L, 330μg/kg
Benzo(b)fluoranthene		4.8μg/L, nd	10μg/L, 330μG/kg
Benzo (ghi) Perylene		4.1μg/L, nd	10μg/L. 330μg/kg
Benzo (k) Fluoranthene		2.5μg/L, nd	10μg/L, 330μg/kg
Bis (2-Chloroethoxy) Methane		5.3μg/L, nd	10μg/L, 330μg/kg
Bis (2-Chloroethyl) Ether		5.7μg/L, nd	10μg/L, 330μg/kg
Bis (2-Chloroisopropyl) Ether		5.7μg/L, nd	10μg/L, 330μg/kg

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Method Reference[1] Water/Soil	Method Detection Limit[2] Water/Soil	Contract Required Quantitation Limit (CRQL)[3] Water/Soil
HSL Pesticides/PCB's	EPA 608/SW 3520/3550/8080		
PCB-1242		0.5μg/L, nd	0.5μg/L, 20μg/kg
PCB-1254		1.0μg/L, nd	1.0μg/L, 40μg/kg
PCB-1221		0.5μg/L, nd	0.5μg/L, 20μg/kg
PCB-1232		0.5μg/L, nd	0.5μg/L, 20μg/kg
PCB-1248		0.5μg/L, nd	0.5μg/L, 20μg/kg
PCB-1260		1.0μg/L, nd	1.0μg/L, 40μg/kg
PCB-1016		0.5μg/L, nd	0.5μg/L, 20μg/kg
a-Endosulfan (alpha)		0.05μg/L, nd	0.05μg/L, 20μg/kg
B-Endosulfan (beta)		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
Endosulfan sulfate		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
a-BHC (alpha)		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
B-BHC (beta)		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
Y-BHC (gamma)		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
-BHC (delta)		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
Aldrin		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
Dieldrin		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
4,4,'-DDD		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
4,4'DDE		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
4,4'-DDT		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
Endrin		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
Endrin ketone		0.10μg/L, nd	0.10μg/L, 4.0μg/kg
Heptachlor		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
Heptachlor epoxide		0.05μg/L, nd	0.05μg/L, 2.0μg/kg
Chlordane		0.5μg/L, nd	0.5μg/L, 20μg/kg
Methoxychlor		0.5μg/L, nd	0.5μg/L, 20μg/kg
Toxaphene		1.0μg/L, nd	1.0μg/L, 40μg/kg

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Method Reference[1] Water/Soil	Method Detection[2] Limit Water/Soil	Contract Required Quantitation Limit (CRQL)[3] Water/Soil
Bis (2-Ethylhexyl) Phthalate		2.5µg/L, nd	10µg/L, 330µg/kg
4-Bromophenyl Phenyl Ether		1.9µg/L, nd	10µg/L, 330µg/kg
Butyl Benzyl Phthalate		2.5µg/L, nd	10µg/L, 330µg/kg
2-Chloronaphthalene		1.9µg/L, nd	10µg/L, 330µg/kg
4-Chlorophenyl Phenyl Ether		4.2µg/L, nd	10µg/l, 330µg/kg
Chrysene		2.5µg/L, nd	10µg/L, 330µg/kg
Dibenzo (a,h) Anthracene		2.5µg/L, nd	10µg/L, 330µg/kg
1,2-Dichlorobenzene		1.9µg/L, nd	10µg/L, 330µg/kg
1,3-Dichlorobenzene		1.9µg/L, nd	10µg/L, 330µg/kg
1,4-Dichlorobenzene		4.4µg/L, nd	10µg/L, 330µg/kg
3-3'Dichlorobenzidine		16.5µg/L, nd	20µg/L, 660µg/kg
Diethyl Phthalate		1.9µg/L, nd	10µg/L, 330µg/kg
Dimethyl Phthalate		1.6µg/L, nd	10µg/L, 330µg/kg
Di-N-Butyl Phthalate		2.5µg/L, nd	10µg/L, 330µg/kg
2,4-Dinitrotoluene		5.7µg/L, nd	10µg/L, 330µg/kg
2,6-Dinitrotoluene		1.9µg/L, nd	10µg/L, 330µg/kg
Di-N-Octyl Phthalate		2.5µg/L, nd	10µg/L, 330µg/kg
1,2-Diphenylhydrazine (as Azobenzene)		nd, nd	nd, nd
Fluoranthene		2.2µg/L, nd	10µg/L, 330µg/kg
Fluorene		1.9µg/L, nd	10µg/L, 330µg/kg
Hexachlorobenzene		1.9µg/L, nd	10µg/L, 330µg/kg
Hexachlorobutadiene		0.9µg/L, nd	10µg/L, 330µg/kg
Hexachlorocyclopentadiene		10µg/L, nd	10µg/L, 330µg/kg
Hexachloroethane		1.6µg/L, nd	10µg/L, 330µg/kg

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Method Reference[1] Water/Soil	Method Detection[2] Limit Water/Soil	Contract Required Quantitation Limit (CRQL)[3] Water/Soil
Indeno (1,2,3 cd) Pyrene		3.7μg/L, nd	10μg/L, 330μg/kg
Isophorone		2.2μg/L, nd	10μg/L, 330μg/kg
Naphthalene		1.6μg/L, nd	10μg/L, 330μg/kg
Nitrobenzene		1.9μg/L, nd	10μg/L, 330μg/kg
N-Nitrosodimethylamine		10μg/L, nd	10μg/L, 330μg/kg
N-Nitrosodi-N-Propylamine		10μg/L, nd	10μg/L, 330μg/kg
N-Nitrosodiphenylamine		1.9μg/L, nd	10μg/L, 330μg/kg
Phenanthrene		5.4μg/L, nd	10μg/L, 330μg/kg
Pyrene		1.9μg/L, nd	10μg/L, 330μg/kg
1,2,4-Trichlorobenzene		1.9μg/L, nd	10μg/L, 330μg/kg
Priority Pollutant Acid Extractables	EPA 625/SW 3520/3550/8270		
2-Chlorophenol		3.3μg/L, nd	10μg/L, 330μg/kg
2,4-Dichlorophenol		2.7μg/L, nd	10μg/L, 330μg/kg
2,4-Dimethylphenol		2.7μg/L, nd	10μg/L, 330μg/kg
4,6-Dinitro-o-cesol		24μg/L, nd	50μg/L, 1600μg/kg
2,4-Dinitrophenol		42μg/L, nd	50μg/L, 1600μg/kg
2-Nitrophenol		3.6μg/L, nd	50μg/L, 1600μg/kg
4-Nitrophenol		2.4μg/L, nd	50μg/L, 1600μg/kg
p-Chloro-m-cresol		3.0μg/L, nd	20μg/L, 666μg/kg
Pentachlorophenol		3.6μg/L, nd	10μg/L, 330μg/kg
Phenol		1.5μg/L, nd	10μg/L, 330μg/kg
2,4,6-Trichlorophenol		2.7μg/L, nd	10μg/L, 330μg/kg

TABLE 3-7

HSL COMPOUNDS
ANALYSES, METHOD REFERENCES, AND METHOD DETECTION LIMITS
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

1 "Water" Methods refer to 40 CFR 136 test method approved for water and wastewater under the Clean Water Act only. "Soil" methods are for groundwater, soil, sediment and sludge analyses under RCRA and related Acts. The detection limits are the same for EPA and SW 846 water analyses.

2 The method dectection limit cited is the routinely best achievable instrument detection limit in clean matrices.

3 The CRQL limits meet the USEPA Contract Lab Program Requirements.

NOTES

EPA (organic parameters) refer to Appendix A to 40 CFR 136, "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," October 26, 1984.

EPA (inorganic parameters) refers to "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020, March 1979, revised March 1983.

SW refers to "Test Methods for Evaluating Solid Waste-Physical/Chemical Methods," SW-846, 3rd Edition.

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION

Monitoring Well:	DL	1A				1B				1C			
Sampling Round:		1	2	3	4	1	2	3	4	1	2	3	4
Volatile Fraction:				NS				NS				NS	
Vinyl Chloride	10		6.8J		15		15		9J		5.9J		7J
Chloroethane	10						1.5J						
Methylene Chloride	5	3.8J				2.8J	4.8J		1J	2.8J	1.9J		
Acetone	10		6.2JB				10B						
Trans-1,2-Dichloroethene	5	6.8	4.4J			4.1J	7.6			5.1	4.2J		
1,2-Dichloroethene (total)	5				1J				4J				2J
Trichloroethene	5	1.0J											
Benzene	5		1.1J		3J				2J				2J
Tetrachloroethene	5	1.8J	1.0J										
Toluene	5												
Ethyl Benzene	5												
Total Xylenes	5												
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
1,2-Dichloropropane	5												
Semivolatile Fraction:				NA			NA	NS			NA	NS	
4-Methylphenol	20												
Naphthalene	20	11											
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20	9.2J	12J			7.8J				4.8J			
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:			NA	NS			NA	NS			NA	NS	
None Detected													

DL - Detectable Limit
J - Estimated value. Used when mass spectral data indicates the presence of a compound that meets identification criteria but the result is less than the specified detection limit but greater than zero.
B - Analyte was found in blank as well as sample; indicates possible/probable blank contamination.

NS - Not sampled.
NA - Not Analyzed
No value given means analyte not detected.
Monitoring Well clusters 10 thru 15 were installed following the completion of Round 3.

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		2A				2B				4			
Sampling Round:		1	2	3	4	1	2	3	4	1	2	3	4
Volatile Fraction:				NS				NS				NS	
	DL												
Vinyl Chloride	10	38	41		24								
Chloroethane	10	10	7.0J		7J				7J				
Methylene Chloride	5	4.6J	3.6J		2J	2.8J				3.8J			
Acetone	10	4.3J	10B				6.4			10			
Trans-1,2-Dichloroethene	5	3.7J	1.3J										
1,2-Dichloroethene (total)	5												
Trichloroethene	5												
Benzene	5	3.3J	3.4J		5	3.4J	2.4J		5				
Tetrachloroethene	5												
Toluene	5	3.3J											
Ethyl Benzene	5	5.9	2.9J						10				
Total Xylenes	5	4.4J	2.1J			12			12				
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5						2.8J						
1,2-Dichloropropane	5												
Semivolatile Fraction:				NS			NA	NS			NA	NS	
4-Methylphenol	20	10J											
Naphthalene	20												
Diethylphthalate	20	9.8J				16.0J							
bis(2-ethylhexyl)phthalate	20	37	4.6J			5.8J							
1,4-Dichlorobenzene	20		3.0J										
Pesticide / PCB Fraction:			NA	NS			NA	NS			NA	NS	
None Detected													

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		3A				3B				3C			
Sampling Round:		1	2	3	4	1	2	3	4	1	2	3	4
Volatile Fraction:	DL			NS				NS				NS	
Vinyl Chloride	10	8.5J	14		16		8.7J		3J				
Chloroethane	10												
Methylene Chloride	5						1.1J			5.9			
Acetone	10		9.3JB				5.9JB						
Trans-1,2-Dichloroethene	5		1.4J			2.4J	5.3						
1,2-Dichloroethene (total)	5								4J				
Trichloroethene	5												
Benzene	5	1.2J	1.1J		2J		1.0J		1J				
Tetrachloroethene	5												
Toluene	5												
Ethyl Benzene	5				1J								
Total Xylenes	5				2J								
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
1,2-Dichloropropane	5												
Semivolatile Fraction:			NA	NS			NA	NS			NA	NS	
4-Methylphenol	20												
Naphthalene	20												
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20	43				4.0J				5.4J			
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:			NA	NS			NA	NS			NA	NS	
None Detected													

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		5A				5B				5C			
Sampling Round:		1	2	3	4	1	2	3	4	1	2	3	4
Volatile Fraction:	DL			NS				NS				NS	
Vinyl Chloride	10												
Chloroethane	10												
Methylene Chloride	5				3								2
Acetone	10												
Trans-1,2-Dichloroethene	5												
1,2-Dichloroethene (total)	5												
Trichloroethene	5												
Benzene	5												
Tetrachloroethene	5												
Toluene	5												
Ethyl Benzene	5												
Total Xylenes	5												
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
1,2-Dichloropropane	5												
Semivolatile Fraction:			NA	NS			NA	NS			NA	NS	
4-Methylphenol	20												
Naphthalene	20												
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20	8.7J				5.6J							
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:			NA	NS			NA	NS			NA	NS	
None Detected													

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		6A				6B			
Sampling Round:		1	2	3	4	1	2	3	4
Volatile Fraction:				NS				NS	
	DL								
Vinyl Chloride	10								
Chloroethane	10								
Methylene Chloride	5				2J	3.7J			1J
Acetone	10					6.1J			11B
Trans-1,2-Dichloroethene	5								
1,2-Dichloroethene (total)	5								
Trichloroethene	5								
Benzene	5								
Tetrachloroethene	5								
Toluene	5								
Ethyl Benzene	5								
Total Xylenes	5								
1,1,1-Trichloroethane	5								
1,1-Dichloroethane	5								
Chlorobenzene	5								
1,2-Dichloropropane	5								
Semivolatile Fraction:			NA	NS			NA	NS	
4-Methylphenol	20								
Naphthalene	20								
Diethylphthalate	20								
bis(2-ethylhexyl)phthalate	20					14.0J			
1,4-Dichlorobenzene	20								
Pesticide / PCB Fraction:			NA	NS			NA	NS	
None Detected									

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		7A				7B			
Sampling Round:	DL	1	2	3	4	1	2	3	4
Volatile Fraction:		NS				NS			
Vinyl Chloride	10		8.6J		12				
Chloroethane	10				3				
Methylene Chloride	5		3.3J	3.2J	2				
Acetone	10							4.7JB	
Trans-1,2-Dichloroethene	5		5.2						
1,2-Dichloroethene (total)	5								
Trichloroethene	5								
Benzene	5								
Tetrachloroethene	5		2.2J						
Toluene	5								
Ethyl Benzene	5								
Total Xylenes	5								
1,1,1-Trichloroethane	5								
1,1-Dichloroethane	5								
Chlorobenzene	5								
1,2-Dichloropropane	5								
Semivolatile Fraction:		NS		NA		NS		NA	
4-Methylphenol	20								
Naphthalene	20								
Diethylphthalate	20								
bis(2-ethylhexyl)phthalate	20								
1,4-Dichlorobenzene	20								
Pesticide / PCB Fraction:		NS		NA		NS		NA	
None Detected									

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		8A				8B				8C			
Sampling Round:		1	2	3	4	1	2	3	4	1	2	3	4
Volatile Fraction:		NS				NS				NS			
	DL												
Vinyl Chloride	10												
Chloroethane	10												
Methylene Chloride	5												
Acetone	10			8.3J									
Trans-1,2-Dichloroethene	5												
1,2-Dichloroethene (total)	5												
Trichloroethene	5												
Benzene	5												
Tetrachloroethene	5												
Toluene	5												
Ethyl Benzene	5												
Total Xylenes	5												
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
1,2-Dichloropropane	5												
Semivolatile Fraction:		NS		NA		NS		NA		NS		NA	
4-Methylphenol	20												
Naphthalene	20												
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20		4.0J				5.8J				6.4J		
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:		NS		NA		NS		NA		NS		NA	
None Detected													

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		9A				9B				9C			
Sampling Round:		1	2	3	4	1	2	3	4	1	2	3	4
Volatile Fraction:		NS				NS				NS			
	DL												
Vinyl Chloride	10												
Chloroethane	10												
Methylene Chloride	5												4
Acetone	10				3				5				
Trans-1,2-Dichloroethene	5												
1,2-Dichloroethene (total)	5												
Trichloroethene	5												
Benzene	5												
Tetrachloroethene	5												
Toluene	5												
Ethyl Benzene	5												
Total Xylenes	5												
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
1,2-Dichloropropane	5												
Semivolatile Fraction:		NS		NA		NS		NA		NS			
4-Methylphenol	20												
Naphthalene	20												
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20		8.2J				3.4J						
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:		NS		NA		NS		NA		NS			
None Detected													

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Monitoring Well:		10A	11A	11B	12B	13A	13B	14A	15A	15B	15C
Sampling Round:		4	4	4	4	4	4	4	4	4	4
Volatile Fraction:	DL										
Vinyl Chloride	10			4J	67		39				
Chloroethane	10			1J	4J						
Methylene Chloride	5				2J		5				1J
Acetone	10										4J
Trans-1,2-Dichloroethene	5										
1,2-Dichloroethene (total)	5				3J		37				
Trichloroethene	5						4J				
Benzene	5				5		2J				
Tetrachloroethene	5						10				
Toluene	5				3J						1J
Ethyl Benzene	5										
Total Xylenes	5				3J						
1,1,1-Trichloroethane	5						1J				
1,1-Dichloroethane	5				4J		5				
Chlorobenzene	5										
1,2-Dichloropropane	5				2J						
Semivolatile Fraction:		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol	20										
Naphthalene	20										
Diethylphthalate	20										
bis(2-ethylhexyl)phthalate	20										
1,4-Dichlorobenzene	20										
Pesticide / PCB Fraction:		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
None Detected											

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

		Round 4						Round 5			
		FB-1	FB-2	FB-3	TB-1	TB-2	TB-3	FB-1	FB-2	TB-1	TB-2
Volatile Fraction:								Not yet available			
	DL										
Vinyl Chloride	10										
Chloroethane	10										
Methylene Chloride	5	2BJ				2BJ					
Acetone	10					5J					
Trans-1,2-Dichloroethene	5										
1,2-Dichloroethene (total)	5										
Trichloroethene	5										
Benzene	5										
Tetrachloroethene	5										
Toluene	5										
Ethyl Benzene	5										
Total Xylenes	5										
1,1,1-Trichloroethane	5										
1,1-Dichloroethane	5										
Chlorobenzene	5										
1,2-Dichloropropane	5										
Semivolatile Fraction:											
4-Methylphenol	20										
Naphthalene	20										
Diethylphthalate	20										
bis(2-ethylhexyl)phthalate	20										
1,4-Dichlorobenzene	20										
Pesticide / PCB Fraction:											
None Detected											

FB - Field Blank
TB - Trip Blank

TABLE 3-8

ORGANIC HSL CONTAMINANTS DETECTED IN MONITORING WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

		Round 1				Round 2				Round 3			
		FB-1	FB-2	TB-1	TB-2	FB-1	FB-2	TB-1	TB-2	FB-1	FB-2	TB-1	
Volatile Fraction:													
	DL												
Vinyl Chloride	10												
Chloroethane	10												
Methylene Chloride	5	3.2J	2.2J	3.2J		2.3J	1.6J				86B		
Acetone	10		1.7J			12B			4.3JB		120B		
Trans-1,2-Dichloroethene	5												
1,2-Dichloroethene (total)	5												
Trichloroethene	5												
Benzene	5												
Tetrachloroethene	5												
Toluene	5												
Ethyl Benzene	5												
Total Xylenes	5												
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
1,2-Dichloropropane	5												
Semivolatile Fraction:													
4-Methylphenol	20												
Naphthalene	20												
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20		180										
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:													
None Detected													

FB - Field Blank
TB - Trip Blank

TABLE 3-9

ORGANIC HSL CONTAMINANTS DETECTED IN RESIDENTIAL WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION

Residential Well:		[redacted]														
Sampling Round:		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Volatile Fraction:		NS		NS	NS			NS		NS	NS		NS	NS		NS
	DL															
Vinyl Chloride	10														41	
Chloroethane	10															
Methylene Chloride	5								4.1J			1.4J				
Acetone	10											7.2JB				
Trans-1,2-Dichloroethene	5								3.0J						35	
Trichloroethene	5														6.8	
Benzene	5														1.3J	
Tetrachloroethene	5								4.5J						7.5	
Toluene	5															
Ethyl Benzene	5															
Total Xylenes	5															
1,1,1-Trichloroethane	5								1.4J							
1,1-Dichloroethane	5														3.2J	
Chlorobenzene	5															
Semivolatile Fraction:		NS		NS	NS			NS		NS	NS		NS	NS		NS
4-Methylphenol	20															
Naphthalene	20															
Diethylphthalate	20															
bis(2-ethylhexyl)phthalate	20															
1,4-Dichlorobenzene	20															
Pesticide / PCB Fraction:		NS		NS	NS			NS		NS	NS		NS	NS		NS
None Detected																

DL - Detectable Limit
J - Estimated value. Used when mass spectral data indicates the presence of a compound that meets identification criteria but the result is less than the specified detection limit but greater than zero.

B - Analyte found in blank as well as sample; indicates poss./prob. blank contamination.
NS - Not sampled. NA - Not Analyzed.
No value given means analyte not detected.

TABLE 3-9

ORGANIC HSL CONTAMINANTS DETECTED IN RESIDENTIAL WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Residential Well:		[redacted]														
Sampling Round:		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Volatile Fraction:		NS	NS		NS	NS		NS	NS		NS	NS		NS	NS	
	DL															
Vinyl Chloride	10															33
Chloroethane	10															
Methylene Chloride	5									4.6J						
Acetone	10															
Trans-1,2-Dichloroethene	5															6.4
Trichloroethene	5															
Benzene	5															1.3J
Tetrachloroethene	5															
Toluene	5															
Ethyl Benzene	5															
Total Xylenes	5															
1,1,1-Trichloroethane	5															
1,1-Dichloroethane	5															
Chlorobenzene	5															
Semivolatile Fraction:		NS	NS		NS	NS		NS	NS		NS	NS		NS	NS	
4-Methylphenol	20															
Naphthalene	20															
Diethylphthalate	20															
bis(2-ethylhexyl)phthalate	20															
1,4-Dichlorobenzene	20															
Pesticide / PCB Fraction:		NS	NS		NS	NS		NS	NS		NS	NS		NS	NS	
None Detected																

TABLE 3-9

ORGANIC HSL CONTAMINANTS DETECTED IN RESIDENTIAL WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Residential Well:		[redacted]											
Sampling Round:		1	2	3	1	2	3	1	2	3	1	2	3
Volatile Fraction:		NS	NS		NS	NS		NS	NS		NS	NS	
	DL												
Vinyl Chloride	10												
Chloroethane	10												
Methylene Chloride	5												
Acetone	10									10			3.7JB
Trans-1,2-Dichloroethene	5												
Trichloroethene	5												
Benzene	5												
Tetrachloroethene	5												
Toluene	5												
Ethyl Benzene	5												
Total Xylenes	5												
1,1,1-Trichloroethane	5												
1,1-Dichloroethane	5												
Chlorobenzene	5												
Semivolatile Fraction:		NS	NS		NS	NS		NS	NS		NS	NS	
4-Methylphenol	20												
Naphthalene	20												
Diethylphthalate	20												
bis(2-ethylhexyl)phthalate	20												
1,4-Dichlorobenzene	20												
Pesticide / PCB Fraction:		NS	NS		NS	NS		NS	NS		NS	NS	
None Detected													

TABLE 3-10

ORGANIC HSL CONTAMINANTS DETECTED IN SURFACE WATER (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION

Sampling Location:		North Pond			South Ditch			West Ditch		
Sampling Round:		1	2	3	1	2	3	1	2	3
Volatile Fraction:	DL	NS	NS		NS	NS		NS	NS	
Vinyl Chloride	10									
Chloroethane	10									
Methylene Chloride	5			5.2B			4.5JB			4.6JB
Acetone	10			8.0JB			7.0JB			5.1JB
Trans-1,2-Dichloroethene	5									
Trichloroethene	5									
Benzene	5									
Tetrachloroethene	5									
Toluene	5									
Ethyl Benzene	5									
Total Xylenes	5									
1,1,1-Trichloroethane	5									
1,1-Dichloroethane	5									
Chlorobenzene	5									
Semivolatile Fraction:		NS	NS		NS	NS		NS	NS	
4-Methylphenol	20									
Naphthalene	20									
Diethylphthalate	20									
bis(2-ethylhexyl)phthalate	20			78JB			88JB			120JB
1,4-Dichlorobenzene	20									
Pesticide / PCB Fraction:		NS	NS		NS	NS		NS	NS	
None Detected										

DL - Detectable Limit

J - Estimated value. Used when mass spectral data indicates the presence of a compound that meets identification criteria but the result is less than the specified detection limit but greater than zero.

B - Analyte found in blank as well as sample; indicates poss./prob. blank contamination.

NS - Not sampled. NA - Not Analyzed.

No value given means analyte not detected.

ses of surface water samples. Inorganic HSL analyses are given in Table 3-11 for monitoring and residential wells. Water quality parameter analyses are given in Table 3-12 for monitoring and residential wells.

Analytical results from wells in each monitoring well cluster are discussed below. Low levels of methylene chloride and/or acetone are present in several of the samples, including blanks, and is assumed to be a result of laboratory contamination of the samples.

> Cluster 1: This cluster is located at the southeast corner of the landfill. Analytical results indicate that all three wells in this cluster are contaminated with varying amounts of volatile and semi volatile organic compounds. Slightly elevated levels of sodium and high specific conductance were also detected during Round 1 sampling. The organic contaminants have been present throughout the sampling program. Contaminant concentration decreases with depth.

> Cluster 2: This well cluster, located east of and adjacent to the landfill, is one of the most contaminated clusters. The shallow A well is contaminated with up to 41 ug/l vinyl chloride. Other solvents and BTX compounds are also present. The levels of contamination in the B well are lower, however there is a slight variation in the suite of contaminants present. This is probably due to physical properties of the contaminants and their exit pathways from the landfill.

> Cluster 3: Cluster 3, located on the northeast corner of the landfill, is contaminated with vinyl chloride, 1,2,-dichloroethene, benzene and bis(2-ethylhexyl) phthalate. Traces of ethyl benzene and xylene are present in the Round 4, A-well sample. Concentrations of contaminants in the cluster decrease with depth with MW-3C apparently free of organic compounds.

> MW-4: MW-4A is a single well located north of the landfill. is free of contaminants. No contaminants have been detected at this location.

> Cluster 5: Cluster 5, upgradient of the landfill, is uncontaminated except for traces of bis(2-ethylhexyl) phthalate detected only during Round 1 sampling.

> Cluster 6: No contamination has been detected at Cluster 6, located south of the landfill.

TABLE 3-11

INORGANIC HSL CONTAMINANTS DETECTED IN MONITORING AND RESIDENTIAL WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION

Kummer/Round 1

		Monitoring Wells:																	
	DL	1A	1B	1C	2A	2B	3A	3B	3C	4	5A	5B	5C	6A	6B	FB-1	FB-2	TB-1	TB-2
Aluminum	22	[65]	[50]	[137]	[59]	[28]	[65]	U	[64]	[51]	[78.0]	[152]	[104]	[53]	[53]	208	409	[44]	[34]
Antimony	35	U	U	U	U	U	U	U	U	U	U	U	U	U	31U	U	U	U	U
Arsenic	2.5	U	U	U	20	15	25	[5.4]	U	U	U	[3.9]	[6.2]	U	U	U	U	U	U
Barium	1	[81]	107	[102]	2290	1810	1180	[145]	[59]	[20]	[35]	[4.6]	[66]	[78.0]	[68]	1U	1U	1U	1U
Beryllium	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Cadmium	5	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	6U
Calcium	9	96200	84200	75700	75500	140000	111000	96800	53000	60400	74600	[4660]	54100	104000	50100	[81]	[82]	[54]	[47]
Chromium	6	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Cobalt	6	U	U	U	[7.9]	U	[19]	U	U	U	U	U	U	U	U	U	U	U	U
Copper	1	43E	[14]E*	[14]E	[14]E	[22]E	[14]E	[14]E	[14]E	[14]E	[21]E	[14]E	[14]E	[14]E	[14]E	[14]E	[14]E	[14]E	[14]E
Iron	7	[23]	[43]	509	19500	8840	16100	2580	[37]	[13]	[9.2]	[11]	[7.6]	[30]	[10]	[36.0]	[30]	[12.0]	[8.4]
Lead	3.4	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Magnesium	126	25200	27800	23500	54900	60800	33800	33400	15500	16400	18600	[814]	16000	20400	14900	U	U	U	U
Manganese	2	21	823	447	486	630	778	474	288	21	18.0	[6.5]	247	[2.2]	224	U	U	U	U
Mercury	0.2	U	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.3	U	U	0.3	0.3	0.3	0.3	0.3	0.4	0.3
Nickel	31	U	[35]	U	47	U	[40]	U	U	U	U	U	U	U	U	U	U	U	U
Potassium	1011	[2090]	[2350]	[2420]	44600	11800	22200	[2430]	[1730]	[1680]	904	1011U	[1610]	[1310]	1960	U	U	U	U
Selenium	1.9	N	28U,N	U,E,N	28U,N	28U,E,N	U,N	28U,N	28U,E,N	U	U,N	U,N	U,N	U,N	U,N	U,N	2.8U,N	2.8U,N	2.8U,N
Silver	5	U	U	U	U	U	[5.1]	U	U	U	12	U	U	[9.1]	U	U	[8.3]	U	U
Sodium	1630	17600	48200	29500	121000	121000	46800	21600	5570	U	[2110]	U	[4470]	6740	19700	U	U	U	U
Thallium	7.4	N	N	U,N	U,N	U,N	U,N	U,N	U	U,N	U,N	U	U,N	U,N	U,N	U,N	U,N	U	U,N
Vanadium	2	U	U	[2.3]	[3.0]	[4.6]	[2.0]	[2.0]	U	U	U	U	U	U	U	U	U	U	U
Zinc	3	74E	822E	78E	128E	614E	32E	136E	36E	35.0E	128.0E	26E	204E	33E	93.0E	27E	22E	21.0E	[26]E
Cyanide	10	27@	U@	U@	U@	U@	U@	U@	U@	U@	U@	60@	U@	U@	U@	NR	U@	NR	U@

Footnotes:

DL - Detection Limit Value, or as noted

Value - If the result is a value greater than or equal to the instrument detection limit but less than the contract required detection limit, report the value in brackets (i.e., [10]).

U - Indicates element was analyzed for but not detected. Report with the detection limit value if different from that shown under DL column (e.g. 10U).

E - Indicates a value estimated or not reported due to the presence of interference.

N - Indicates spike sample recovery is not within control limits.

@ - Preservation pH was not greater than 12 prior to analysis, although the sample was basic. Losses of the analyte would be expected to be minimal.

NR - Not Required

TABLE 3-11

INORGANIC HSL CONTAMINANTS DETECTED IN MONITORING
AND RESIDENTIAL WELLS (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Kummer/Round 2 Analyses

Monitoring Wells:

	DL	7A	7B	8A	8B	8C	9A	9B	9C	[redacted]							
Aluminum	23	U	[25]	U	U	U	U	[136]	744	U	U	U	U	U	U	U	U
Antimony	53	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Arsenic	1.8	15	11	[4.7]	[6.9]	[4.1]	[9.6]	[5.0]	[5.4]	[4.0]	[8.8]	[3.6]	[6.2]	[6.7]	U	U	U
Barium	1.0	1070	[36]	[47]	[71]	[59]	[64]	[31]	[72]	[59]	[36]	[53]	[30]	[40]	U	U	U
Beryllium	1.0	U	U	U	[1.5]	U	U	U	[1.5]	[1.5]	U	U	U	U	U	U	U
Cadmium	5.0	U	U	U	U	U	U	U	U	U	5.1	U	U	U	U	U	U
Calcium	9.0	95900	42200	60800	64100	52000	90900	66400	64700	85000	58400	79400	50700	90000	[58]	[24]	[47]
Chromium	9.0	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Cobalt	1.0	U	[2.3]	U	U	[1.4]	U	[2.3]	U	U	U	U	U	U	U	U	[1.2]
Copper	2.0	U	[3.2]	U	U	U	U	[3.1]	U	45	[24]	[8.0]	[24]	[7.9]	U	U	[2.2]
Iron	2.0	287	[6.4]	[6.9]	[21]	248	[5.2]	[8.6]	[64]	[33]	[8.7]	[9.0]	[30]	432	[6.0]	[13]	[10]
Lead	3.0	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Magnesium	73	29200	10900	15200	16700	14500	18500	17700	17400	18700	14900	21100	12800	24200	U	U	U
Manganese	1.0	1100	39	[8.0]	398	256	[5.3]	[15]	302	U	U	U	U	[15]	U	U	U
Mercury	0.2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Nickel	38	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Potassium	1000	U	[1060]	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Selenium	2.5	N	N	N	N	N	N	N	N	N	N	N	E,N	N	N	N	N
Silver	4.0	U	[4.1]	U	U	U	U	[5.3]	U	U	U	U	U	U	U	U	[5.9]
Sodium	1950	31000	9530	U	U	U	16100	U	U	7300	U	U	U	5910	U	U	U
Thallium	2.6	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Vanadium	4.0	U	[7.3]	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Zinc	4.0	354	56	[16]	[12]	101	[16]	[15]	53	58	45	26	53	767	[20]	[8.1]	59

Footnotes:

- DL - Detection Limit Value, or as noted.
- Value - If the result is a value greater than or equal to the instrument detection limit but less than the contract required detection limit, report the value in brackets (i.e., [10]).
- U - Indicates element was analyzed for but not detected. Report with the detection limit value if different from that shown under DL column (e.g. 100).
- E - Indicates a value estimated or not reported due to the presence of interference.
- N - Indicates spike sample recovery is not within control limits.

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 1
KUMMER LANDFILL REMEDIAL INVESTIGATION

Parameter	MDL	Bottle Blank	Travel Blank	MW-1A	MW-1B	MW-1C
Alkalinity, mg/l	1	ND	ND	280	430	280
Ammonia Nitrogen, mg/l	0.1	ND	ND	ND	ND	ND
Nitrite Nitrogen, mg/l	0.1	ND	ND	0.2	ND	ND
Nitrate Nitrogen, mg/l	0.1	ND	ND	4.8	ND	ND
Total Kjeldahl Nitrogen, mg/l	0.1	ND	ND	0.6	0.6	0.2
pH*	-			7.5	7.3*	7.3
Dissolved Oxygen*, mg/l	-			3.2	1.7	-
Conductance*, umhos/cm^2	-			680	1100	660

Parameter	MDL	MW-2A	MW-2B	FB-2	MW-3A
Alkalinity, mg/l	1	570	790	ND	500
Ammonia Nitrogen, mg/l	0.1	19	5.6	ND	7.2
Nitrite Nitrogen, mg/l	0.1	ND	ND	ND	ND
Nitrate Nitrogen, mg/l	0.1	ND	ND	ND	ND
Total Kjeldahl Nitrogen, mg/l	0.1	21	7.3	ND	7.2
pH*	-	7.1**	6.9**		6.8
Dissolved Oxygen*, mg/l	-	1.3	1.5		1.2
Conductance*, umhos/cm^2	-	1700	2000		1200

Parameter	MDL	MW-3B	MW-3C	MW-4	MW-5A
Alkalinity, mg/l	1	350	190	190	230
Ammonia Nitrogen, mg/l	0.1	ND	ND	ND	ND
Nitrite Nitrogen, mg/l	0.1	ND	ND	ND	ND
Nitrate Nitrogen, mg/l	0.1	ND	ND	0.2	5.0
Total Kjeldahl Nitrogen, mg/l	0.1	0.6	0.9	ND	0.4
pH*	-	7.2	7.5	7.4	7.3
Dissolved Oxygen*, mg/l	-	2.2	1.3	2.2	8.8
Conductance*, umhos/cm^2	-	780	370	400	460

Parameter	MDL	MW-5B	MW-5C	MW-6A	MW-6B
Alkalinity, mg/l	1	190	190	280	200
Ammonia Nitrogen, mg/l	0.1	ND	ND	ND	ND
Nitrite Nitrogen, mg/l	0.1	ND	ND	ND	ND
Nitrate Nitrogen, mg/l	0.1	ND	ND	1.6	ND
Total Kjeldahl Nitrogen, mg/l	0.1	ND	ND	ND	ND
pH*	-	8.3	7.6	7.2	8.3
Dissolved Oxygen*, mg/l	-	2.4	1.7	2.8	1.4
Conductance*, umhos/cm^2	-	340	380	630	410

* From Field Log Data Sheets

** Laboratory pH measurement

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 2
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

	MDL	7A	7B	8A	8B	8C
Alkalinity, mg/l	1.0	360	160	190	230	190
Ammonia N, mg/l	0.1	ND	ND	ND	ND	ND
Nitrate N, mg/l	0.1	ND	ND	2.0	ND	ND
Nitrite N, mg/l	0.1	ND	ND	ND	ND	ND
TKN, mg/l	0.1	0.4	0.4	0.1	0.1	0.1
pH		7.3	8.2	-	7.5	-
D.O., mg/l		-	-	3.4	2.6	-
Conductance, umhos/cm^2		840	320	400	450	360

	9A	9B	9C	[redacted]	
Alkalinity	290	230	220	180	250
Ammonia N	ND	ND	ND	ND	ND
Nitrate N	6.9	ND	ND	0.2	3.0
Nitrite N	ND	ND	ND	ND	ND
TKN	0.3	ND	ND	ND	0.3
pH	-	-	-	-	-
D.O.	-	-	3.8	-	-
Conductance	620	440	440	-	-

	[redacted]			FB	TB
Alkalinity	200	190	290	ND	ND
Ammonia N	ND	ND	ND	ND	ND
Nitrate N	1.8	1.8	ND	ND	ND
Nitrite N	ND	ND	ND	ND	ND
TKN	0.3	0.1	0.2	ND	ND

ND - Not Detected

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 3
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Units	MDL	[redacted]		
Alkalinity, Total	mg/L	1	400	240	280
Ammonia Nitrogen	mg/L	0.1	ND	ND	ND
Nitrate Nitrogen	mg/L	0.1	0.1	2.5	2.7
Nitrite Nitrogen	mg/L	0.1	ND	ND	ND
Total Kjeldahl Nitrogen	mg/L	0.1	ND	ND	ND

Parameter	Units	MDL	Travel Blank	[redacted]	
Alkalinity, Total	mg/L	1	ND	240	300
Ammonia Nitrogen	mg/L	0.1	ND	ND	ND
Nitrate Nitrogen	mg/L	0.1	0.1	18	0.1
Nitrite Nitrogen	mg/L	0.1	ND	ND	ND
Total Kjeldahl Nitrogen	mg/L	0.1	ND	ND	ND

Parameter	Units	MDL	[redacted]	
Alkalinity, Total	mg/L	1	200	260
Ammonia Nitrogen	mg/L	0.1	ND	ND
Nitrate Nitrogen	mg/L	0.1	0.1	6.6
Nitrite Nitrogen	mg/L	0.1	ND	ND
Total Kjeldahl Nitrogen	mg/L	0.1	ND	ND

Parameter	Units	MDL	3516 Irvine	3406 Irvine	3511 Cedar
Alkalinity, Total	mg/L	1	230	200	200
Ammonia Nitrogen	mg/L	0.1	ND	ND	ND
Nitrate Nitrogen	mg/L	0.1	0.1	4.1	1.9
Nitrite Nitrogen	mg/L	0.1	ND	ND	ND
Total Kjeldahl Nitrogen	mg/L	0.1	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 4
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Units	MDL	MW-1A	MW-1B	MW-1C
Alkalinity, Total	mg/L	1	290	510	330
Dissolved Oxygen (Field)	mg/l	0.1	1.6	1.2	1.6
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	6.4	0.1	ND
Nitrogen, Nitrite	mg/L	0.1	0.1	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	850	910	540
Temperature (Field)	Degrees C	0.5	7.5	8.0	8.0
pH (Field)	units	0.1	7.4	7.9	7.4

Parameter	Units	MDL	MW-2A	MW-2B	MW-3A
Alkalinity, Total	mg/L	1	660	880	610
Dissolved Oxygen (Field)	mg/l	0.1	0.8	1.6	1.1
Nitrogen, Ammonia	mg/L	0.1	18	12	7.0
Nitrogen, Kjeldahl	mg/L	0.1	21	14	13
Nitrogen, Nitrate	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	1550	1820	960
Temperature (Field)	Degrees C	0.5	8.0	9.0	6.0
pH (Field)	units	0.1	6.4	6.1	7.1

Parameter	Units	MDL	MW-3B	MW-3C	MW-4A
Alkalinity, Total	mg/L	1	290	200	190
Dissolved Oxygen (Field)	mg/l	0.1	1.9	3.5	7.6
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	500	300	310
Temperature (Field)	Degrees C	0.5	7.0	7.0	6.0
pH (Field)	units	0.1	7.8	8.2	7.9

Parameter	Units	MDL	MW-5A	MW-5B	MW-5C
Alkalinity, Total	mg/L	1	330	220	200
Dissolved Oxygen (Field)	mg/l	0.1	8.8	1.6	2.0
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	3.0	ND	ND
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	300	300	290
Temperature (Field)	Degrees C	0.5	6.0	6.5	7.0
pH (Field)	units	0.1	7.7	8.8	7.6

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 4
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Units	MDL	MW-6A	MW-6B	MW-7A
Alkalinity, Total	mg/L	1	420	230	350
Dissolved Oxygen (Field)	mg/l	0.1	6.0	2.9	5.3
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	3.9	0.2	0.1
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	660	340	610
Temperature (Field)	Degrees C	0.5	6.0	6.0	5.0
pH (Field)	units	0.1	6.9	8.0	7.4

Parameter	Units	MDL	MW-7B	MW-8A	MW-8B
Alkalinity, Total	mg/L	1	190	200	220
Dissolved Oxygen (Field)	mg/l	0.1	4.2	8.0	1.6
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	1.6	ND
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	280	300	340
Temperature (Field)	Degrees C	0.5	5.0	7.0	7.0
pH (Field)	units	0.1	7.6	8.1	7.9

Parameter	Units	MDL	MW-8C	MW-9A	MW-9B
Alkalinity, Total	mg/L	1	210	280	250
Dissolved Oxygen (Field)	mg/l	0.1	2.1	5.0	4.6
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	8.5	0.6
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	300	490	360
Temperature (Field)	Degrees C	0.5	7.0	7.0	7.0
pH (Field)	units	0.1	7.3	8.3	7.6

Parameter	Units	MDL	MW-9C	MW-10A	MW-11A
Alkalinity, Total	mg/L	1	260	210	380
Dissolved Oxygen (Field)	mg/l	0.1	--	0.5	1.4
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	ND	0.3
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	380	370	740
Temperature (Field)	Degrees C	0.5	7.0	4.0	4.5
pH (Field)	units	0.1	7.5	7.9	7.6

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 4
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Units	MDL	MW-11B	MW-12B	MW-13A
Alkalinity, Total	mg/L	1	290	520	230
Dissolved Oxygen (Field)	mg/l	0.1	1.2	4.3	7.6
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	0.3	6.3
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	470	860	610
Temperature (Field)	Degrees C	0.5	6.0	8.0	6.0
pH (Field)	units	0.1	8.0	6.8	8.0

Parameter	Units	MDL	MW-13B	MW-14A	MW-15A
Alkalinity, Total	mg/L	1	370	210	210
Dissolved Oxygen (Field)	mg/l	0.1	2.8	7.4	8.8
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	0.6	0.3	2.6
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	720	310	620
Temperature (Field)	Degrees C	0.5	7.0	8.0	8.0
pH (Field)	units	0.1	8.2	7.8	7.8

Parameter	Units	MDL	MW-15B	MW-15C	Travel Blank
Alkalinity, Total	mg/L	1	240	150	ND
Dissolved Oxygen (Field)	mg/l	0.1	6.3	3.6	-
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	4.7	0.1	ND
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND
Specific Conductivity (Field)	umhos/cm2	10	610	810	-
Temperature (Field)	Degrees C	0.5	7.0	6.0	-
pH (Field)	units	0.1	7.6	7.5	-

Parameter	Units	MDL	Travel Blank	Travel Blank	Field Blank #1
Alkalinity, Total	mg/L	1	ND	ND	2
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrite	mg/L	0.1	ND	ND	ND

TABLE 3-12

WATER QUALITY DATA FOR MONITORING
AND RESIDENTIAL WELLS - ROUND 4
KUMMER LANDFILL REMEDIAL INVESTIGATION
(Continued)

Parameter	Units	MDL	Field Blank #2	Field Blank #3	Dup 1
Alkalinity, Total	mg/L	1	2	2	290
Nitrogen, Ammonia	mg/L	0.1	ND	ND	ND
Nitrogen, Kjeldahl	mg/L	0.1	ND	ND	ND
Nitrogen, Nitrate	mg/L	0.1	ND	ND	6.3
Nitrogen, Nitrite	mg/L	0.1	ND	ND	0.1

Parameter	Units	MDL	Dup 2	Dup 3
Alkalinity, Total	mg/L	1	660	520
Nitrogen, Ammonia	mg/L	0.1	18	ND
Nitrogen, Kjeldahl	mg/L	0.1	20	ND
Nitrogen, Nitrate	mg/L	0.1	ND	0.3
Nitrogen, Nitrite	mg/L	0.1	ND	ND

Cluster 7: MW-7A, located about 1500 feet east of the landfill, is slightly contaminated. Analytical results have not been consistent although vinyl chloride was detected during both Rounds 2 and 4. No contaminants have been detected in MW-7B.

Cluster 8: Samples collected during Round 2 from each well in this cluster contained bis(2-ethylhexyl) phthalate. Other sampling rounds have shown the location (about 1500 feet east of the landfill) to be uncontaminated.

Cluster 9: Analyses of samples obtained from wells in Cluster 9 are similar to those in Cluster 8, although no contaminants have ever been detected in MW-9C. This cluster is located about 2000 feet southeast of the landfill.

MW-10: No contaminants have been detected in MW-10A, located about 2000 feet northeast of the landfill.

Cluster 11: This cluster is located about 500 feet east of the landfill. The shallow A-well is uncontaminated whereas MW-11B contains traces of vinyl chloride and chloroethane. The two wells are separated by a low permeability layer which is apparently large enough in areal extent to isolate the upper portion of the water table. Contaminants are believed to be transported laterally at the B-depth.

MW-12: MW-12B, screened across both A and B depths and located near the eastern perimeter of the landfill, is one of the most highly contaminated monitoring wells at the site. Although Round 5 results are not available to confirm the results of Round 4, it is apparent that contaminated ground water is migrating east away from the landfill. The levels of contamination may have been increased by drawing contaminated water towards the well during the pumping test. Vinyl chloride is present in the well at a concentration of 67 ug/l.

Cluster 13: This cluster is located southeast of the landfill and is situated in a slight depression. The deeper B-well shows very high levels of contamination while the A-well is clean. This apparent anomaly may be the result of the slight downward flow gradient present at the location. Because the cluster is situated in the low area runoff and snow melt tends to pond around it. This surface water may flush the A zone as it recharges the aquifer.

MW-14: MW-14A, located north of the TV Station, is uncontaminated.

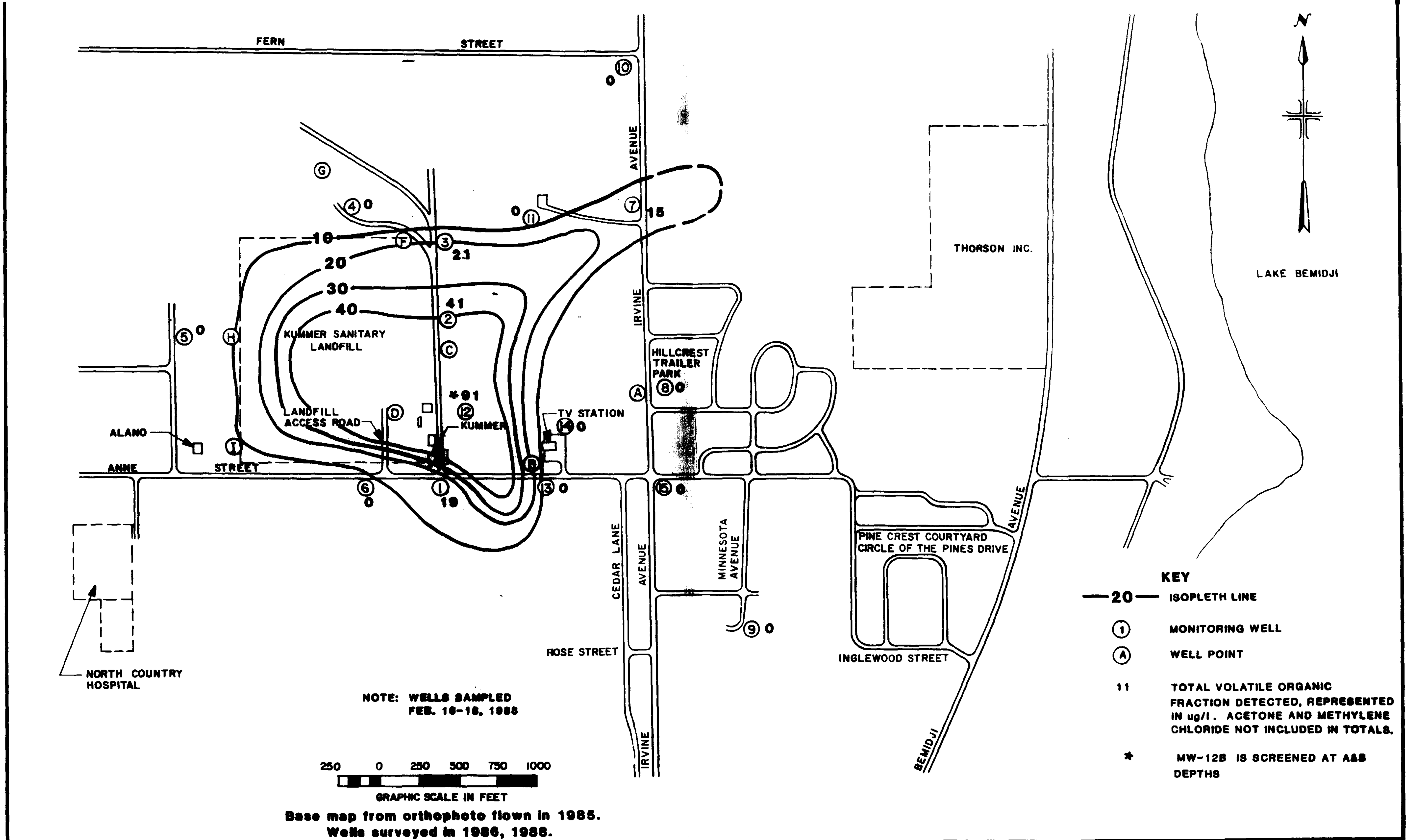
Cluster 15: This cluster is at the intersection of Anne Street and Irvine Avenue. All three wells in this cluster are believed to be free of contaminants. Although 1 ug/l of toluene was detected in MW-15C this may be a sampling or lab error and will not be consider present unless confirmed during subsequent sampling rounds.

3.8.3 Summary of Ground Water Contamination and Migration

Recent investigations into the magnitude and extent of ground water contamination in Northern Township suggest that volatile organic compounds are being introduced into the shallow ground water from the Kummer Sanitary Landfill. This is based on the results of the monitoring well installation programs conducted in 1986 and 1988, and subsequent sampling of these wells and selected residential wells.

Lateral ground water movement is generally east from the landfill, as indicated on Figures 3-8 through 3-12. Wells upgradient of the landfill (Cluster 5) have shown no contamination in three rounds of sampling. However, an examination of ground water quality data in Tables 3-8, 3-11, and 3-12 and on Figures 3-14, 3-15 and 3-16 show that ground water quality is adversely affected as ground water flows east past the landfill. Organic contaminants which were not detected in Cluster 5 wells were found in monitoring wells immediately downgradient of the land-
fill. These include vinyl chloride, trans-1,2-dichloroethylene, tetrachloroethylene, trichloroethylene, benzene, ethyl benzene, and xylene. Inorganic analyses show a similar trend in which contaminants found typically in landfill leachate are present in concentrations significantly greater in downgradient monitoring wells than in the upgradient wells. The contaminants include calcium, iron, magnesium, potassium, manganese, and sodium. Specific conductance and pH also show similar trends.

The contamination appears to be limited to water which has passed beneath the fill in the upper 30 to 50 feet of the aquifer. Though a downward vertical hydraulic gradient exists west of and under the landfill, the gradient changes immediately



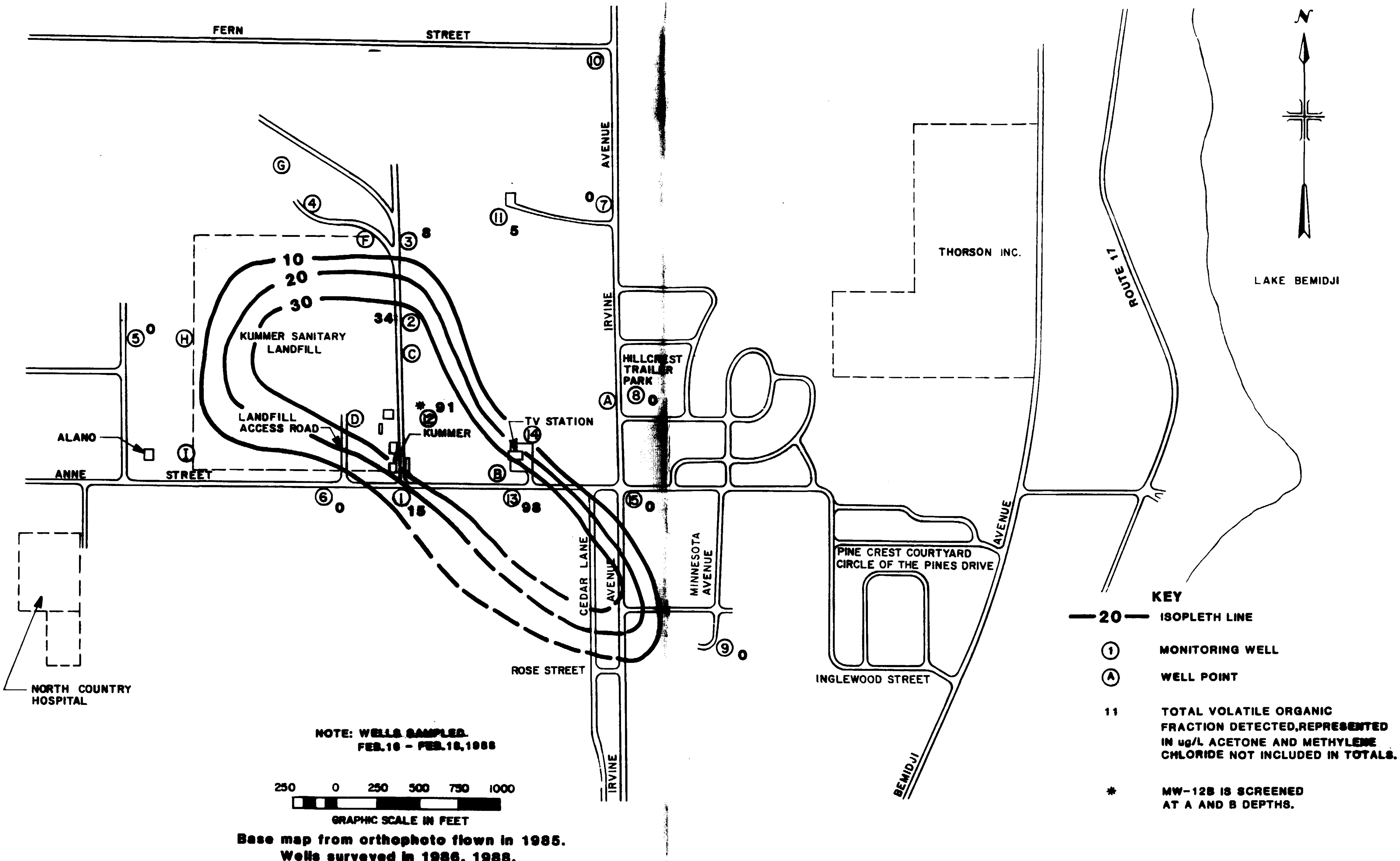
MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

CONTAMINANT ISOPLETH MAP
A-DEPTH WELLS-ROUND 4

MALCOLM PIRNIE, INC.

FIGURE 3-14



KEY

—20—	ISOPLETH LINE
(1)	MONITORING WELL
(A)	WELL POINT
11	TOTAL VOLATILE ORGANIC FRACTION DETECTED,REPRESENTED IN ug/L ACETONE AND METHYLENE CHLORIDE NOT INCLUDED IN TOTALS.
*	MW-12B IS SCREENED AT A AND B DEPTHS.

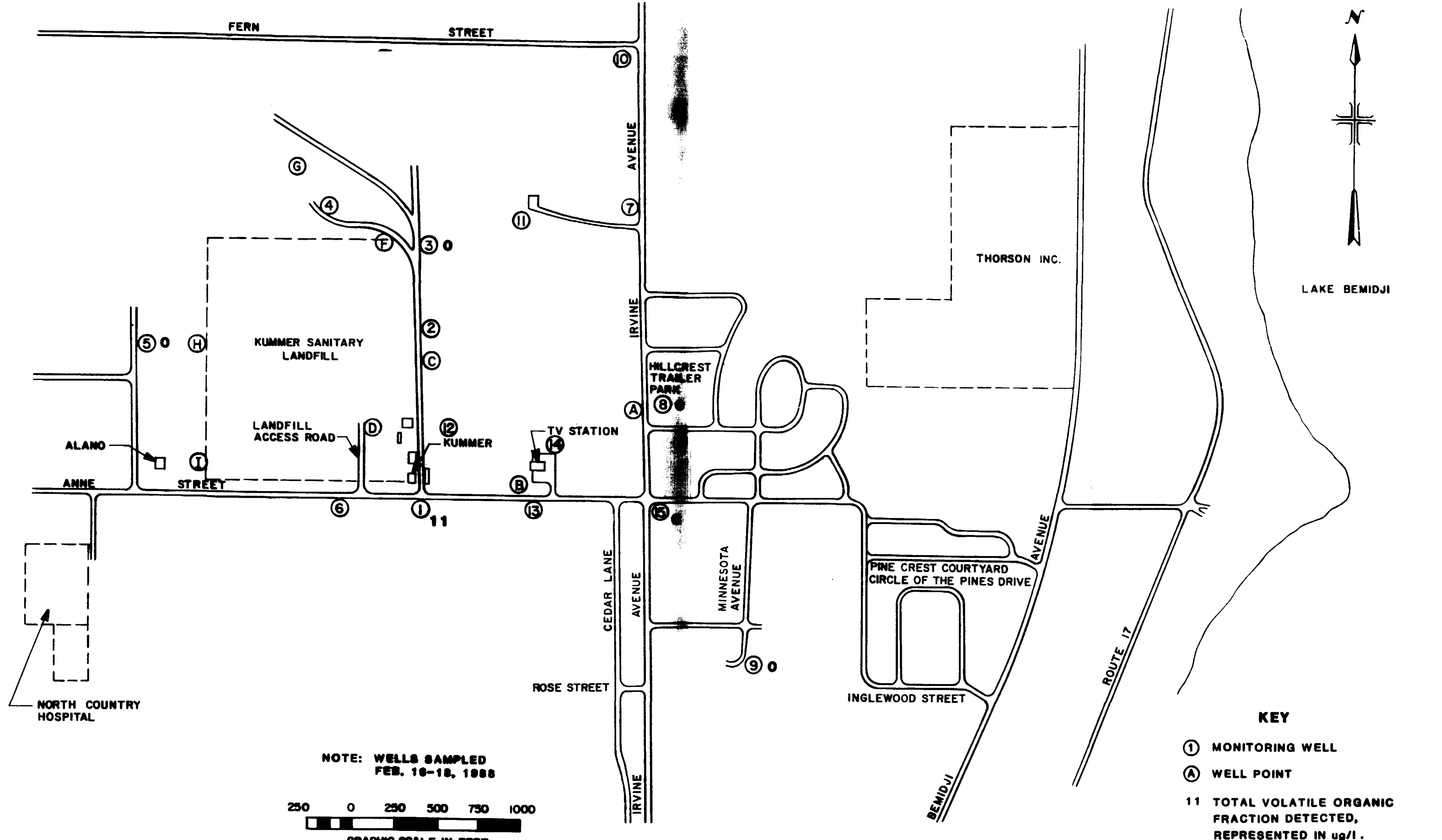
MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

CONTAMINENT ISOPLETH MAP
B - DEPTH WELLS - ROUND 4

MALCOLM PIRNIE, INC.

FIGURE 3-15



NOTE: WELLS SAMPLED
FEB. 16-18, 1988

Base map from orthophoto flown in 1985.
Wells surveyed in 1986, 1988.

KEY

① MONITORING WELL

Ⓐ WELL POINT

11 TOTAL VOLATILE ORGANIC FRACTION DETECTED, REPRESENTED IN ug/l. ACETONE & METHYLENE CHLORIDE NOT INCLUDED IN TOTALS.

MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

CONTAMINANT OCCURRENCES
C-DEPTH WELLS-ROUND 4

MALCOLM PIRNIE, INC.

FIGURE 3-16

east of or beneath the landfill. The upward vertical hydraulic gradient which exists in the aquifer east of the landfill (see Figure 3-10) retards the movement of contaminants into deeper zones of the aquifer in this area. However, low concentrations of volatile organic compounds have been detected in two water samples from MW-1C, screened from 57 to 62 feet below grade at the southeast corner of the landfill. This well cluster is located in the area where the vertical hydraulic gradient changes from downward to upward. Ground water in the deeper zone of the aquifer may be contaminated in this area, but it is expected to move into the shallower zones of the aquifer as it moves downgradient. No contamination has been found in the deeper zone of the aquifer downgradient of MW-1C.

Contamination has been detected intermittently in shallow monitoring wells located more than 1,000 feet east of the landfill, including MW-9, which is located in the area of residential well contamination. These intermittent occurrences may be a result of the contaminants entering the ground water in slugs, due to precipitation events or seasonal influences.

Ground water moves generally east from the landfill to the residential area discharging ultimately into Lake Bemidji. An approximate average ground water discharge velocity of 0.03 to 0.24 feet per day is calculated from an estimated hydraulic conductivity of 10 to 20 feet per day for the outwash sands of the aquifer and a gradient of 0.0030 to 0.012 feet per foot derived from ground water altitude contour maps.

The extent of ground water contamination is believed to be limited to a zone east and slightly north and south of the landfill, extending to the residential area east of Irvine Street. The exact limits of the plume towards the east are unknown, however, as a result of not having monitoring wells to bracket this zone.

3.9 LEACHATE AND SOILS INVESTIGATION

The sandy soil used for covering the landfill has a relatively high permeability, especially when reworked during excavation and covering operations. A cover with relatively high permeability would provide an avenue by which precipitation would enter the landfill and come in contact with waste materials, generating leachate. The same sandy soil is expected to underlie the landfill, allowing vertical downward migration of leachate directly into the water table beneath the landfill.

In some areas of the landfill, especially the former borrow pits and fill trenches, excavation may have continued down to the water table. In those areas, the landfill material would be in direct contact with the ground water system, at least seasonally and perhaps constantly. Such direct contact may be enhanced by the apparent mounding of water beneath the landfill. In this case leachate would migrate immediately according to ground water flow dynamics at any particular location.

Horizontal migration of leachate may be along impermeable layers of landfilled materials. However, this is not expected to generate measurable quantities of leachate escaping at the landfill perimeters, and leachate from the landfill was not observed at the surface at any time during on-site investigative activities. No samples of leachate in the landfill were obtained during the remedial investigation.

Soil sediment samples were collected from three locations during Round 3. These included sediment from a pond located adjacent to the north side of the landfill in what appears to be a barrow area, a drainage ditch immediately to the south of the landfill along Anne Street, and another ditch along the west side of the landfill perpendicular to Anne Street. The ditches were dry during the sample survey. The sample locations are shown in Plate I. Samples from these locations were submitted to CompuChem Laboratories for full HSL analyses. Analytical results are given in Table 3-13. A review of those results indicates the samples were not contaminated.

TABLE 3-13

ORGANIC HSL CONTAMINANTS DETECTED
IN SOIL/SEDIMENT SAMPLES (ug/l)
KUMMER LANDFILL REMEDIAL INVESTIGATION

Sampling Location:		North Pond			South Ditch			West Ditch		
Sampling Round:		1	2	3	1	2	3	1	2	3
Volatile Fraction:	DL									
Vinyl Chloride	10	NS	NS		NS	NS		NS	NS	
Chloroethane	10	NS	NS		NS	NS		NS	NS	
Methylene Chloride	5	NS	NS	5.2B	NS	NS	4.5JB	NS	NS	4.6JB
Acetone	10	NS	NS	8.0JB	NS	NS	7.0JB	NS	NS	5.1JB
Trans-1,2-Dichloroethene	5	NS	NS		NS	NS		NS	NS	
Trichloroethene	5	NS	NS		NS	NS		NS	NS	
Benzene	5	NS	NS		NS	NS		NS	NS	
Tetrachloroethene	5	NS	NS		NS	NS		NS	NS	
Toluene	5	NS	NS		NS	NS		NS	NS	
Ethyl Benzene	5	NS	NS		NS	NS		NS	NS	
Total Xylenes	5	NS	NS		NS	NS		NS	NS	
1,1,1-Trichloroethane	5	NS	NS		NS	NS		NS	NS	
1,1-Dichloroethane	5	NS	NS		NS	NS		NS	NS	
Chlorobenzene	5	NS	NS		NS	NS		NS	NS	
Semivolatile Fraction:										
4-Methylphenol	20	NS	NS		NS	NS		NS	NS	
Naphthalene	20	NS	NS		NS	NS		NS	NS	
Diethylphthalate	20	NS	NS		NS	NS		NS	NS	
bis(2-ethylhexyl)phthalate	20	NS	NS	78JB	NS	NS	88JB	NS	NS	120JB
1,4-Dichlorobenzene	20	NS	NS		NS	NS		NS	NS	
Pesticide / PCB Fraction:										
None Detected		NS	NS		NS	NS		NS	NS	

Notes:

DL - Detectable Limit
J - Estimated value. Used when mass spectral data indicates the presence of a compound that meets identification criteria but the result is less than the specified detection limit but greater than zero.
B - Analyte was found in blank as well as sample; indicates possible/probable blank contamination.
NS - Not sampled.
No value given means analyte not detected.

4.0 HAZARDOUS SUBSTANCES INVESTIGATION

4.1 HAZARDOUS SUBSTANCES, POLLUTANTS, OR CONTAMINANTS

4.1.1 Types and Locations

The problem of primary importance in the vicinity of the Kummer Sanitary Landfill is the contamination of ground water with volatile organic compounds. This contaminated ground water regime may continue to be used as a source of potable water by nearby residents of the landfill. Of the contaminants detected during the RI, contaminants of concern were selected based on a number of criteria including presence in a residential well, presence and frequency of detection in the monitoring wells, and their toxicity. The following volatile organic compounds have been identified as contaminants of concern. The concentration range of these compounds in both monitoring wells and residential wells is also provided.

	Range Detected (ug/l)
- Tetrachloroethylene	1.0 - 10
- Trichloroethylene	1.0 - 6.8
- Trans-1,2,-Dichloroethylene	1.3 - 35
- Vinyl Chloride	5.9 - 67
- Benzene	1.0 - 5

Important physical characteristics of these compounds are listed in Table 4-1. All known or suspected carcinogenic compounds have been identified as contaminants of concern, as was one noncarcinogenic compound, trans-1,2-dichloroethylene. Public health and environmental concerns associated with these contaminants are discussed in detail in Section 8.0. The remaining contaminants are not evaluated further due to one or more of the following reasons: non detection in a residential well; infrequency of detection in a residential well or monitoring well; low toxicity relative to the contaminants of concern; detection of low concentrations relative to existing or proposed health-based criteria. Exclusion of the remaining contaminants, such as ethyl benzene and xylene, from further evaluation will not appreciably

TABLE 4-1

PHYSICAL CHARACTERISTICS OF CONTAMINANTS OF CONCERN
KUMMER LANDFILL REMEDIAL INVESTIGATION

CONTAMINANT	MOLECULAR WEIGHT	BOILING POINT (°C)	MELTING POINT (°C)	SPECIFIC GRAVITY	SOLUBILITY IN WATER (mg/l)	HENRY'S LAW CONSTANT*
Tetrachloroethylene	165.83	121.0	- 19.0	1.6227	175	2.87×10^{-2}
Trichloroethylene	131.29	87.0	- 73.0	1.4642	1,000	8.92×10^{-3}
Trans-1,2-Dichloroethylene	97.0	48.0	- 50.0	1.270	700	5.32×10^{-2}
Vinyl Chloride	62.50	- 13.37	- 153.8	0.9195	574,000	3.6×10^{-2}
Benzene	78.11	80.1	5.51	0.879	1,780	5.5×10^{-3}

* atm-m^3/mole @ 77°F

alter the public health and environmental evaluation based on the contaminants of concern.

4.1.2 Physical States and Locations

Contaminants observed during investigative activities of the RI were solely found dissolved in ground water samples. These samples were obtained from locations outside the boundaries of the Kummer Sanitary Landfill. It is noted that at ambient temperature, the volatile organic contaminants detected with the exception of vinyl chloride are normally found in a liquid state. Investigative activities conducted within the landfill were limited to sampling of surface water and sediments as described in Section 5 of this report. Because subsurface work was not conducted within the landfill, it is not possible to determine the actual physical state(s) of waste materials which may have caused contamination of ground water and soils. It is also not possible to determine whether the wastes contributing to ground water contamination are present in bulk quantities or are dispersed in small, household quantities throughout the landfill. Vinyl chloride is a degradation product of tetrachloroethylene and trichloroethylene as discussed further in Section 4.5.1 below. Vinyl chloride can be formed in-situ in the landfill or in ground water as a result of microbial action. Therefore, vinyl chloride while observed in a dissolved state may also exist in a gaseous state at this site.

It can be concluded, though, that the location of the source of ground water contamination is the Kummer Sanitary Landfill. This is evidenced since the monitoring wells in well cluster 5 located immediately upgradient of the landfill were not found to be contaminated, while those well clusters immediately downgradient (1, 2, and 3) were contaminated. There is no other possible source between the uncontaminated and contaminated monitoring wells.

4.1.3 Quantities

The quantity of wastes located within the landfill which contribute to ground water contamination cannot be determined with the information currently available.

4.2 MEDIUMS AFFECTED

4.2.1 Soil

Surface soil material found off-site was not subjected to quantitative analysis. It has been assumed that the source of contamination detected in ground water is mixed municipal refuse located in the Kummer Sanitary Landfill. Since this material cannot impact surrounding surface soils, it can be reasonably concluded that soil surface material from areas surrounding the landfill are not contaminated. It is noted, though, that the possibility exists for surface soils to become contaminated as a result of rising contaminated ground water. In such a situation, wetland soils or stream sediments when inundated may become contaminated. The most likely locations for this to occur is the wetland area immediately north and northeast of the landfill. Monitoring well cluster 7 is located along the eastern periphery of this wetland. Results in Table 3-7 indicate the presence of vinyl chloride, trans-1,2,-dichloroethene, and tetrachloroethylene in one of two samples taken from the shallow well of that cluster. It is possible, therefore, that wetland soil sediments are being exposed to contamination and may become contaminated in the process. Analyses of wetland soil sediments have not yet been performed to verify this possibility. As discussed below in Section 5.0, Surface Water and Sediment Investigation, soil sediments from three locations around the landfill were analyzed but did not exhibit contamination.

The possible impact of contaminated ground water on wetland soil sediments will be further evaluated following review of Round 6 analytical results. It is anticipated that wetland surface sediments will be sampled in Round 6 during high ground water periods.

4.2.2 Ground Water

Ground water downgradient (or east) of the landfill has been found to be contaminated with those compounds described in Section 4.1.1 above. Contamination is generally found in the upper levels of the ground water aquifer.

4.2.3 Surface Water

Surface water was not present during sampling surveys conducted during the RI. The closest areas of occasional surface water to the landfill are a pond located in a former borrow area immediately north of the fill area and two ditches along the south and west perimeter of the fill area. Given the nature of site problems, it is unlikely that surface water, when present, is adversely affected.

4.2.4 Air

Air monitoring conducted as part of this RI was performed as a health and safety requirement during drilling activities using a photoionization detector. Monitoring of this type is insufficient to determine whether ambient air is adversely affected by gas emissions from the landfill and poses chronic health risks. Therefore it is not possible to document whether ambient air has been affected. This concern is discussed further in Section 6.0, Air Investigation.

4.3 PATHWAYS OF MIGRATION

It appears the main pathway of migration of contaminants is through leaching of waste materials located within the landfill to ground water. Movement of ground water under the landfill from west to east conveys contaminants off-site. Even though the landfill has been closed for several years, this process is apparently still on-going as evidenced by contaminants still found immediately downgradient of the landfill. At that location, it would be expected that the relatively fast movement of ground water would convey leachate past that location if leaching had been a short-lived event. Such a situation in which leaching occurs over a lengthy period of time is not an uncommon phenomenon.

4.4 SOURCES OF RELEASE

The source of contaminant release to ground water is believed to be the waste materials that have been disposed of within the Kummer Sanitary Landfill. The contaminants detected are frequently components of solvents and fuels that are used in a liquid state. It is therefore likely that the wastes contributing the contaminants to the ground water were disposed of in a liquid state also.

4.5 WASTE COMPONENT CHARACTERISTICS

Contamination in the vicinity of the Kummer Sanitary Landfill site is predominantly with volatile organic chemicals. Chlorinated ethylene and BTX (benzene/toluene/xylene) chemical contamination has been detected along the eastern perimeter and further east of the landfill. This section will characterize five such chemicals detected in ground water and of concern to the RI. The following chemicals will be characterized in terms of environmental fate and biological processes including toxicity:

Chlorinated ethylene-based chemicals	BTX-based chemicals
tetrachloroethylene (PCE)	benzene
trichloroethylene (TCE)	
trans-1,2-dichloroethylene	
vinyl chloride	

4.5.1 Environmental Transformation

Chlorinated ethylene-based chemicals - Degradative transformation of PCE through TCE and through one or more dichloroethylene intermediates such as trans-1,2- dichloroethylene and 1,1-dichloroethylene, to vinyl chloride has been suggested (Science Applications International Corporation, 1985). The transformation of these compounds in ground water may occur through biological processes; many factors such as temperature and pH, the type and numbers of microorganisms present and the chemical concentrations may affect the transformation or the rate of transformation.

In soils, especially in soils of low organic content, the chlorinated ethylenes will leak into ground water. PCE and TCE adsorb to soils with high levels of organics; sorption is probably an insignificant fate process for trans-1,2-dichloroethylene and vinyl chloride. It is unclear if PCE and TCE bound to organic material can be degraded by microorganisms or if they must be desorbed to be degraded.

The most important transport and fate process for the chlorinated ethylenes in the upper layer of soil and surface water is volatilization into the atmosphere where they can react with hydroxyl (OH^-) radicals to produce hydrochloric acid, carbon monoxide, carbon dioxide and carboxylic acid.

The chlorinated ethylenes can be bioaccumulated to some degree and there is some evidence that they can be metabolized by higher organisms. Bioaccumulation and biodegradation do not appear to be important environmental fate processes for vinyl chloride (Clement Associates, Inc., 1985).

Benzene - Sorption, leaching and biodegradation are environmental fate processes for benzene introduced to soils. The log octanol/water partition coefficient for benzene indicates that it will sorb to sedimentary organic material (USEPA, 1979) and sorption processes are likely removal mechanisms in both ground water and surface waters. Benzene has a relatively high water solubility and a low soil-water distribution coefficient; therefore, benzene is expected to leach from soils of low organic content (USEPA, 1984). Benzene may be utilized as a source of carbon by some bacteria for short periods of time. Gradual biodegradation by a variety of microorganisms probably occurs, the rate of which may be enhanced by the presence of other hydrocarbons (USEPA, 1985).

Volatilization is the primary transport process for benzene introduced to aquatic systems. Environmental conditions, such as water turbulence, effect the rate of volatilization. Bioaccumulation in aquatic organisms is low at observed environmental concentrations (USEPA, 1979). Once introduced to the atmosphere, benzene may be rapidly photooxidized (Clement Associates, Inc., 1985). Photolysis is an unlikely fate process.

4.5.2 Pharmakokinetics, Metabolism and Toxicity

A summary of information on the kinetics, metabolism and toxicity of the chemicals of concern is presented by chemical.

The metabolism and relative reactivity of the metabolic products of chlorinated ethylenes are of interest because of evidence that the metabolites are the cause of functional impairment and tissue damage in various organs (National Academy of Sciences, 1983). The symmetrical chlorinated ethylenes, including PCE, are postulated to be more resistant to metabolism and to the formation of reactive intermediates than are the unsymmetrical members of the series (Politzer et al., 1981 as reported in National Academy of Science, 1983). It is thought that the hepatotoxicity of the chlorinated ethylenes is inversely related to the stability of the compound to biotransformation. The first step in the metabolism of the chlorinated ethylenes is postulated to be the formation of an epoxide, a highly reactive intermediate with alkylating properties.

Tetrachloroethylene or PCE (CCl_2CCl_2) - PCE is a moderately volatile chlorinated hydrocarbon which has important applications in the dry cleaning of fabrics and in the degreasing of fabricated metal parts. It is nearly insoluble in water but is highly lipophilic.

PCE is rapidly and virtually completely absorbed following oral administration, presumably because of its lipid solubility; pulmonary uptake of PCE during inhalation exposure is linearly proportional to exposure duration and the concentration in air. Absorption of PCE during vapor or liquid contact with the skin of experimental animals or man is very slow (USEPA, 1985). PCE distributes widely into body tissues and readily crosses the blood brain barrier and placental barrier.

PCE metabolism in man and animals is rate dependent (metabolism decreases with increases in dose) and saturable. While limited metabolism of PCE occurs, the principal site of metabolism is in the liver where PCE is oxidized to PCE oxide which rearranges to trichloroacetic acid. PCE metabolites have been shown to covalently bind to cellular macromolecules such as protein and lipid. Cumulative cellular changes may result in humans subject to chronic exposure since tissue-bound metabolites have a slow rate of turnover. Covalent binding and hepatotoxicity of PCE are directly proportional to metabolized dose.

Most of the human toxicological data for PCE is derived from accidental and occupational exposures to high, often unknown, ambient concentrations. Although a wide variety of toxic effects have been observed, the effects on the central nervous system are the most noticeable. Effects on the liver and kidneys, some of which have occurred after an enlapsed period of time, have also been noted (USEPA, 1985). The effects are similar to those observed in laboratory animals following acute, subchronic and chronic exposure to PCE. Additional adverse effects in humans may include irritation of the mucous membranes and intoxication. The mammalian tests performed to date do not indicate any significant teratogenic potential of PCE; the teratogenic potential of PCE for humans is unknown. Although mutagenicity studies of PCE in microbial test systems have produced inconclusive or negative results, PCE epoxide, a reactive metabolite of PCE, has been found to be mutagenic. Negative results were obtained in one in vivo cytogenetics study in humans (Ikeda et al., 1980 as reported in National Academy of Sciences, 1983).

The USEPA classifies PCE as a Group B2 probable human carcinogen via both oral and inhalation routes of exposure. The classification is based on the results of a bioassay conducted by the National Cancer Institute in which PCE administered by gavage increased the incidence of liver tumors in mice, the results of a bioassay conducted by the National Toxicology Program in which PCE administered through inhalation was shown to induce carcinogenic effects in both rats and mice, negative results in a number of other animal studies and mixed results from a number of short-term studies designed to evaluate mutagenic potential (USEPA, 1986). It is generally recognized that the carcinogenic potential of PCE resides in its biologically reactive metabolites rather than in the PCE compound itself and the tumorigenic response is assumed to be directly related to metabolized dose.

Human epidemiological investigations of PCE carcinogenicity are marred by problems in design and methodology and by lack of adequate exposure data. These studies have primarily been carried out on people employed in the dry cleaning and laundry industries and suggest an increased risk of pancreatic and kidney cancers (USEPA, 1985).

In terms of relative potency, PCE ranks in the lowest quartile among 55 suspected or known carcinogens evaluated by the USPEA Carcinogen Assessment Group.

Trichloroethylene or TCE ($CHClCCl_2$) - The pharmakokinetics and metabolism of TCE have been studied in man as well as in animals. TCE absorption after oral ingestion is virtually complete; TCE absorption from inhalation increases in proportion to the duration of exposure and concentration in air (USEPA, 1985). The compound distributes widely into body tissues and is eliminated via liver metabolism to urinary metabolites. In man, metabolism of TCE is linearly proportional to the inhaled dose and there is no indication that the metabolism is saturation dependent. While studies have not been made of TCE metabolism in man after oral exposure, at the concentrations typically found or expected in drinking water, TCE is expected to be completely absorbed and metabolized. Metabolic processes are similar to those described for PCE; TCE metabolism proceeds at a much slower rate in humans than in laboratory animals.

While the teratogenic potential of TCE for humans cannot be directly extrapolated from animal studies, exposure of various gestating laboratory animals to levels greatly in excess of those generally found in the environment has not been observed to result in any teratogenic effects. Available data provide suggestive evidence that commercial grade TCE is a weakly active, indirect mutagen causing effects in a number of different test systems.

The USEPA classifies TCE as a Group B2 probable human carcinogen (sufficient animal evidence of carcinogencity and inadequate human evidence) via both oral and inhalation routes of exposure. Some uncertainty exists, however within the national and international scientific communities as to the classification of TCE as a carcinogen. The interpretation of the incidence of liver tumors in studies involving male mice is the cause of the uncertainty. The induction of tumors in both sexes of mice in multiple studies, the incidence of other tumor types in mice, some evidence of mutagenicity and binding with DNA are the bases of the conservative classification. There are no adequate epidemeologic data in humans. The carcinogenic potential of TCE is generally considered to reside in cellular-reactive intermediate metabolites. Based on relative potency, TCE ranks in the lowest quartile among the 55 suspect or known carcinogens evaluated by the USEPA Carcinogen Assessment Group.

trans-1,2-Dichloroethylene (ClCHCHCl) - 1,2-Dichloroethylene exists in both the cis and trans forms. Based on studies with TCE, virtually complete absorption of trans-1,2- dichloroethylene from oral exposure can be assumed. It has been demonstrated in an isolated, perfused rat liver preparation that both isomers are metabolized to the same metabolites, dichloroacetic acid and dichloroethanol, apparently via an epoxide intermediate (Bonse et al., 1975 as reported in National Academy of Science, 1983).

Both isomers demonstrate a potential for liver and kidney damage, although little information is available on the effects of these compounds from chronic exposure. They possess general anesthetic and narcotic properties at exposure levels above those at which liver and kidney effects are seen. Data on the human health aspects of exposure to trans-1,2-dichloroethylene are unavailable. Trans-1,2-dichloroethylene was non- mutagenic when assayed with E. coli, non-mutagenic in Salmonella tester strains and failed to induce chromosomal abberations in mouse bone marrow cells following intraperitoneal injections. Data are lacking on the teratogenicity and carcinogenicity of 1,2-dichloroethylene.

Long-term studies on the carcinogenic potential of trans-1,2-dichloroethylene have not been carried out and the compound is in Group D, not classified, in the USEPA weight of evidence categories for potential carcinogens (USEPA, 1984).

Vinyl Chloride (CH_2CHCl) - Rapid absorption of vinyl chloride from the gastrointestinal tract into the blood of dosed rats has been reported (USEPA, 1984). Vinyl chloride has been known to have carcinogenic effects in humans and animals from both oral and inhalation routes. It is a Group A human carcinogen (sufficient evidence from epidemiological studies) in the USEPA weight-of evidence categories for potential human carcinogens. In humans, exposure to vinyl chloride is associated with angiosarcoma of the liver. Several tumor types have been reported in animals following exposure to vinyl chloride through ingestion or inhalation. In addition to the liver, organs most likely to be affected are the brain, lung and hemato- and lymphopoietic systems. Toxicity and carcinogenicity are mediated through a metalobic intermediate, with the incidence of effect related to the amount of vinyl chloride metabolized rather than to the concentration of exposure. Vinyl chloride has also been shown to bind to DNA in short-term studies.

Data regarding the teratogenicity of orally administered vinyl chloride are generally not available, however it was not teratogenic when administered via inhalation to rats, mice or rabbits (USEPA, 1984). Data are inadequate to characterize the teratogenicity of vinyl chloride to humans.

Benzene (C_6H_6) - Inhalation is the most frequent route of exposure to benzene and it is readily absorbed into the blood from vapor exposure. Due to its lipid solubility, this compound tends to be distributed largely in fatty tissues. While equilibrium may be rapidly reached between the atmosphere and the blood, saturation of tissues may not be complete until several days after exposure.

Elimination of benzene is primarily through the lung into the atmosphere. There is, in addition, a continuous reestablishment of an equilibrium between the blood and the tissues that have previously stored benzene. Benzene is metabolized by the liver to more water-soluble phenolic compounds which may be excreted as sulfates or glucuronides; a small amount may be excreted as mercapturic acid.

Benzene is a hematological poison. It is toxic to bone marrow which may cause effects ranging from a mild decrease in platelets to aplastic anemia. Benzene has been observed to cause leukemias and decrease serum antibody levels and immune system response.

Acute exposures to benzene have resulted in a wide range of symptoms including irritation of the eyes and respiratory tract and central nervous system depression. Death from acute exposure is usually the result of cardiac or respiratory failure. The major concern associated with chronic human exposure is benzene-induced blood disorders, including leukemia.

Considerable human data are available linking inhalation exposure to benzene with leukemia; animal data concerning the carcinogenicity of inhaled benzene are equivocal (USEPA, 1984). Data regarding cancer incidence in humans following oral exposure to benzene is generally unavailable.

Benzene was negative for mutagenicity in the S. typhimurium assay and inactive in a dominant/lethal assay in rats (NAS, 1980). However, toxic effects on the bone marrow cells of rats and other animals include changes in chromosome number and breakage that resemble those found in humans exposed to benzene.

Humans exposed to benzene have demonstrated a variety of chromosomal abberations including abnormal karyotype and deletion of chromosomal material. Taken as a whole, studies in animals and humans clearly indicate a causal relationship between benzene exposure and chromosomal abnormalities.

USEPA, in a review of teratogenicity studies for benzene, concluded that although chronic exposure to benzene may constitute a fetotoxic or teratogenic hazard, inhalation studies are too inconclusive to either confirm or refute the hypothesis.

Since benzene has been found to have a causal relationship with respect to leukemia in humans, USEPA has classified benzene as a Group A human carcinogen via both inhalation and oral routes of exposure.

5.0 SURFACE WATER AND SEDIMENT INVESTIGATION

The surface water and sediment investigation conducted during this RI was originally limited to sampling and analysis of surface water and sediment from three locations around the landfill. These included the pond located in a borrow area adjacent to the north side of the landfill and two ditches immediately adjacent to the south and west perimeters of the landfill.

During sampling rounds 1, 2, and 3 no surface water was observed at any of these three sites. Consequently, no surface water samples were taken. Sediment samples were taken and submitted for full HSL analyses. No contaminants other than common laboratory contaminants were found in these three samples.

6.0 AIR INVESTIGATION

It was discussed earlier in this report that the contaminants of primary importance described in Section 4.1 may be present in the landfill in either bulk quantities or distributed throughout the landfill in small household amounts. In addition, vinyl chloride is most probably present as a result of biodegradation of those same contaminants. Due to the presence of these volatiles in the landfill, their lack of containment as evidenced by their presence in ground water samples obtained from off-site locations, and the lack of an impermeable landfill cover, there is a possibility that the volatile contaminants may be present in gas emissions from the landfill. Information from other recent and current landfill investigations is showing that volatile hydrocarbons including vinyl chloride in addition to methane are being routinely found in gas emissions from landfills which accepted general municipal refuse.

The air investigation conducted during the Kummer RI was limited to real-time ambient monitoring during drilling activities. The monitoring was performed as an on-going health and safety requirement and to assist in the selection of subsurface soil samples. Air monitoring using a photoionization instrument was conducted in the immediate work area. No positive HNu readings were recorded while drilling at Well Clusters 1-15.

It is recognized that a photoionization detector is not sufficiently sensitive to detect volatile contaminants at levels which may pose chronic health risks. Therefore based on the investigative activities conducted, it is not presently possible to determine what constituents and their concentrations may be found in landfill gas emissions.

An ambient air monitoring program can be conducted to determine that information. Monitoring stations would most likely be located around the perimeter of the landfill and, possibly, within residential and commercial neighborhoods nearby. However, it is highly probable that as a recommendation of the Feasibility Study currently being conducted as part of this

RI/FS, a landfill cover will be proposed and subsequently installed with its primary purpose of minimizing landfill leachate and further degradation of ground water quality. Such a cover will require a gas collection system for the venting of methane, at the least. Either individual or centralized gas exhaust treatment units can be installed on the vents to greatly reduce any volatile constituents from the vent emissions.

It does not seem justified at this time to implement an ambient air monitoring program assuming that a landfill cap will be installed within a relatively short time. If conducted, the information generated from such a program would not significantly affect the justification for a cover since justification is already based on the need to protect ground water quality. However, implementing an air monitoring program should be considered as a basis for generating "before" ambient air quality data for the volatile contaminants of concern prior to construction of a landfill cover and operation of venting and gas treatment. Such information would be useful in evaluating future effects of gas treatment on ambient air quality at the perimeter of the site and in residential neighborhoods.

7.0 BIOTA INVESTIGATION

Possible contamination of biota was not investigated during the RI. Based on a review of background information, it was not warranted to undertake this task due to the nature of the contamination problem at the Kummer Sanitary Landfill.

8.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

This section evaluates potential public health and environmental impacts associated with chemical contamination in ground water at the Kummer Sanitary Landfill site.

Following a brief summary of the analytical results, human receptors that may be affected by the chemical contamination are identified. Public health concerns associated with exposure to the contamination are presented and current site conditions, in the absence of any remedial measures, are evaluated.

Potential environmental impacts, including impacts on Lake Bemidji, are unlikely given the limited extent of low-level chemical contamination in ground water. Chemical contaminants were not detected in ponded water on the landfill and water in the two drainage ditches south and west of the landfill.

While largely qualitative, this evaluation will contribute to the determination of remedial objectives for the site. Guidance in the preparation of this section was obtained from the USEPA Superfund Public Health Evaluation Manual (USEPA, 1986).

8.1 SUMMARY OF ANALYTICAL RESULTS

The analytical results of ground water samples collected from both monitoring wells and private supply wells during the RI are discussed in Section 3.8.2.

Volatile organic chemical contamination was detected in ground water from Monitoring Well Clusters 1, 2 and 3 and MW-12B, located along the eastern perimeter of the Kummer Sanitary Landfill. The chemical contamination is predominantly chlorinated ethylene (tetrachlorethylene, trichloroethylene, trans -1, 2 -dichloroethylene, vinyl chloride) and BTX (benzene/toluene/xylene) based. Evidence of chlorinated ethylene-based contamination was also detected in Monitoring Well Clusters 7, 11, and 13, located east of the landfill.

Volatile organic chemical contamination was also detected in ground water from three private supply wells from residences east of the landfill. The nature of the contamination is similar to that determined in the monitoring wells. Chlorinated ethylene-based contamination and benzene were detected. Vinyl chloride contamination as high as 41 ug/l was detected.

8.2 POTENTIAL RECEPTORS

Northern Township, a largely residential community, uses ground water as its potable supply. Potable water is supplied by private residential and commercial/industrial wells.

An area approximately one mile by one-third mile located downgradient of the landfill, between the landfill and Lake Bemidji, has been considered by MPCA as the "affected area". A current population of 960 persons and projected population of 2,240 persons has been estimated for this area by MPCA.

8.3 HEALTH CONCERNS

The human exposure pathways of concern at the Kummer Sanitary Landfill site are via ground water; exposure may occur via drinking or non-drinking water use of the ground water.

Recently, research has suggested that ingestion of contaminants in drinking water may not constitute the sole or even primary route of exposure (Andleman, 1985; Brown et al., 1984). The release of volatile organic contaminants from bath or shower water can result in inhalation exposures that may be significant when compared to direct ingestion of these contaminants (Andleman, 1985). Similarly, skin absorption of contaminants in water during washing and bathing activities may constitute a significant exposure route compared to direct ingestion (Brown et al., 1984).

Exposure from ingestion involves use of the ground water for drinking and cooking; inhalation exposure to contaminants volatilized from the water may occur during showering. Bathing and routine washing activities do not appear to be viable dermal exposure routes, given the volatility of the chemicals and their low dermal absorption efficiencies.

The maximum concentrations of the chemicals of concern in ground water from private supply wells and monitoring wells, determined during the RI, are presented in Table 8-1. These

TABLE 8-1

COMPARISON OF CONTAMINANT CONCENTRATIONS IN
GROUND WATER TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
(ARARs) AND OTHER CRITERIA
KUMMER LANDFILL REMEDIAL INVESTIGATION

Contaminant	Well Type	Maximum Contaminant Concentration	ARARs	Other Criteria (X denotes exceedance)				
			MCLs	MCLGs	PMCLs	PMCLGs	RALs	AWQC
Tetrachloroethylene			NA	NA	NA	0	6.9	0(0.88)
	Private	7.5				X	X	X
	Monitoring	10				X	X	X
Trichloroethylene			5	0	5	0	31.2	0(2.8)
	Private	6.8	X	X	X	X		X
	Monitoring	LT 4.0		X		X		X
trans-1,2-Dichloroethylene			NA	NA	NA	70	70	NA
	Private	35						
	Monitoring	7.6						
Vinyl chloride			2	0	1	0	0.15	0(2.0)
	Private	41	X	X	X	X	X	X
	Monitoring	67	X	X	X	X	X	X
Benzene			5	0	5	0	12	0(0.67)
	Private	LT 1.3		X		X		X
	Monitoring	5.0		X		X		X

Notes:

MCLs and MCLGs - USEPA Maximum Contaminant Levels and Maximum Contaminant Level Goals.
PMCLs and PMCLGs - USEPA Proposed Maximum Contaminant Levels and Proposed Maximum Contaminant Level Goals.
RALs - Minnesota Department of Health Recommended Allowable Limits.
AWQC - USEPA Ambient Water Quality Criteria for the protection of human health. Adjusted for drinking water only as per USEPA (1986). Concentrations in parentheses correspond to the midpoint (10^{-6}) of the risk range for potential carciongens.
NA - Not available.
LT - Less than.
All unit in ug/l.

concentrations are compared in Table 8-1 to applicable or relevant and appropriate requirements (ARARs) and to other criteria as required by USEPA (USEPA, 1986).

USEPA drinking water maximum contaminant levels (MCLs) developed under the Safe Water Drinking Act are the ARARs of interest to this evaluation. MCLs are maximum permissible levels of contaminants in water delivered to the user of a public water supply and represent allowable lifetime exposure levels for a 70 kg adult ingesting 2 liters of water per day. Other daily sources are considered in the development of MCLs and a margin of safety is added to protect the more sensitive members of the population. The MCLs incorporate technological and economic criteria in addition to health factors.

MCLs have been promulgated for trichloroethylene, vinyl chloride and benzene. The maximum trichloroethylene concentration in the private supply wells exceeds the MCL. The maximum vinyl chloride concentrations in both the private supply wells and the monitoring wells exceed the MCL. The maximum benzene concentration in the monitoring wells is at the MCL.

The other criteria presented in Table 8-1 are USEPA maximum contaminant level goals (MCLGs), proposed MCLs and proposed MCLGs developed under the Safe Water Drinking Act, Minnesota Department of Health (MDH, 1986) Recommended Allowable Limits (RALs), and USEPA ambient water quality criteria for the protection of human health. MCLGs, entirely health- based, are developed by USEPA as part of the process for setting MCLs. They represent the maximum concentrations of contaminants in drinking water at which no known or anticipated adverse effect on the health of persons will occur, and they include an adequate margin of safety. MCLGs are nonenforceable health goals. While MDH indicates that the RALs apply only to private water supply, they are compared to all the data presented in Table 8-1. The RALs for systemic toxicants, in this case trans-1,2-dichloroethylene, are based on the application of safety factors to accepted allowable daily intakes; for compounds classified as known or probable carcinogens, RALs have been calculated at a 10^{-5} (1 in 1 hundred thousand) lifetime incremental risk level. Federal ambient water quality criteria (AWQC) are estimates of ambient surface water concentrations that will not result in adverse human health effects. For suspect or known carcinogens, concentrations associated with a range of incremental cancer risks (10^{-5}, 10^{-6} and 10^{-7}) have been developed, in addition to an absolute criterion of zero. For most chemicals, two exposure pathways are incorporated into the criteria: lifetime ingestion of drinking water (2 liters/day) and ingestion of aquatic organisms (6.5 g/day). AWQCs, adjusted for drinking water only as per USEPA (1986), associated with a 10^{-6} incremental cancer risk are presented in Table 8-1. The AWQC are non-enforceable.

MCLGs of zero have been established for the potential carcinogens trichloroethylene, vinyl chloride, and benzene. The maximum concentrations of these contaminants in ground water from both the private supply wells and the monitoring wells exceed the goals. The proposed MCLs for trichloroethylene and vinyl chloride are exceeded, as is the proposed MCLG for tetrachloroethylene, trichloroethylene, vinyl chloride and benzene. The RALs for tetrachloroethylene and vinyl chloride are also exceeded, indicating lifetime incremental cancer risks greater than 1 in 1 hundred thousand (10^{-5}). Tetrachloroethylene, trichloroethylene, vinyl chloride and benzene levels in ground water exceed the AWQC.

Although not presented in Table 8-1, two inorganic constituents were also found to exceed established federal and Minnesota MCLs. Barium concentrations exceeded the MCL in two monitoring well clusters while the nitrate concentration exceeded the MCL in one private supply well. Nitrates are not usually associated with landfill leachate; the numerous septic tanks in the area may be a cause of high nitrate concentrations in shallow wells.

Contaminant concentrations is ground water are compared in Table 8-2 to toxicity guidelines, where available, that have been developed to evaluate toxic (but not carcinogenic) and carcinogenic health effects. A verified reference dose (RfD, formerly termed the acceptable daily intake or ADI), expressed in terms of milligrams per kilogram body weight per day has been established for tetrachloroethylene (USEPA, 1986). The concentration in ground water that would result in an exceedance of RfD, if ground water is consumed by a 70 kilogram adult at a rate of 2 liter per day, is calculated to be 700 ug/l. The tetrachloroethylene concentrations in the private supply wells and monitoring wells do not exceed this value.

Carcinogenic potency factors based on oral exposure have been developed for tetrachloroethylene, trichloroethylene, vinyl chloride, and benzene. The concentration in ground water that would result in the incremental cancer risk of 10^{-6} (1 in 1 million), if ground water is consumed by a 70 kilogram adult at a rate of 2 liters per day for a 70-year lifetime, are presented in Table 8-2. The maximum concentrations of all four chemicals in both private supply wells and monitoring wells exceed these values.

In summary, contaminant concentrations in ground water downgradient of the Kummer Sanitary Landfill exceed federal and state standards and guidelines for drinking water quality and human exposure. Since private ground water supply wells provide the sole source of water to residents in the vicinity of the site, concern exists for potential adverse health effects associated with the use of the ground water. Such concern must be considered in the development and evaluation of remedial alternatives for the site.

It is anticipated that a community drinking water system will be installed in the affected area of Northern Township by the latter part of 1988. This system will greatly reduce the risk posed to residents by replacing their contaminated water supply with uncontaminated potable water from another source. The proposed potable water supply system will serve an area in Northern Township shown on Figure 8-1.

Ground water generally flows eastward from the landfill as shown on Figures 3-8 through 3-12. It appears from water quality data from well Cluster 7 and MW-10 that the current furthest extent of contaminated ground water to the north lies between

TABLE 8-2

COMPARISON OF MAXIMUM CONTAMINANT CONCENTRATIONS IN
GROUND WATER TO TOXICITY GUIDELINES
KUMMER LANDFILL REMEDIAL INVESTIGATION

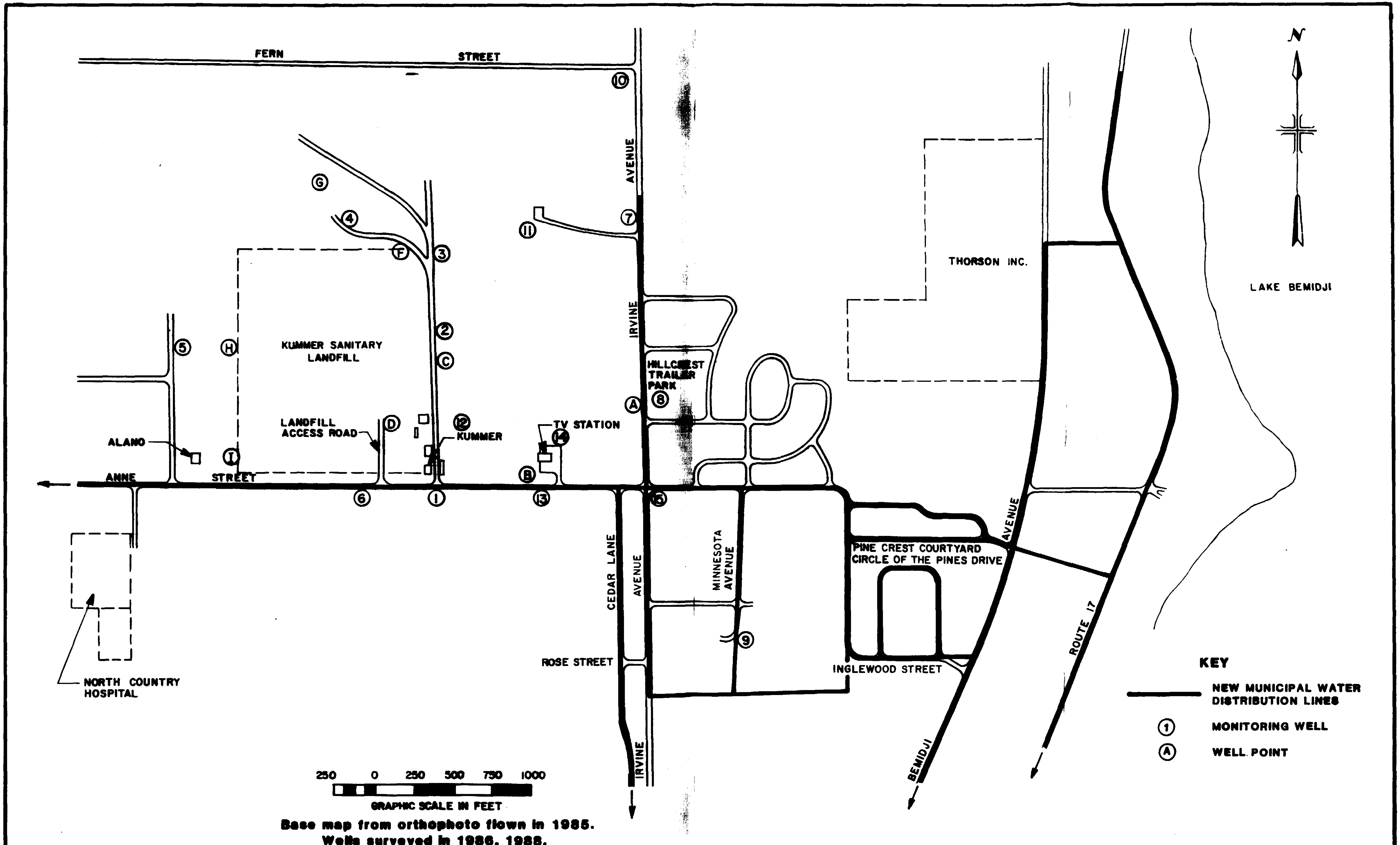
Contaminant	Well Type	Maximum Contaminant Concentration	Toxicity Guidelines (X denotes exceedance): Daily Intake	Toxicity Guidelines (X denotes exceedance): Cancer Risk
Tetrachloroethylene			700	0.7
	Private	7.5		X
	Monitoring	10		X
Trichloroethylene			NA	3.2
	Private	6.8		X
	Monitoring	LT 4.0		X
trans-1,2-Dichloroethylene			NA	NC
	Private	35		
	Monitoring	7.6		
Vinyl chloride			NA	0.02
	Private	41		X
	Monitoring	67		X
Benzene			NA	0.67
	Private	LT 1.3		X
	Monitoring	5.0		X

Notes:

Daily Intake - Concentration in ground water resulting in an exceedance of the verified reference dose (acceptable daily intake) if ground water is consumed by a 70 kg adult at a rate of 2 l per day.

Cancer Risk - Concentration in ground water resulting in an incremental cancer risk of 10^{-6} if ground water is consumed by a 70 kg adult at a rate of 2 l per day for a 70 year lifetime.

NA - Not available.
NC - Not carcinogenic.
LT - Less than.
All unit in ug/l.



MALCOLM PIRNIE

KUMMER LANDFILL REMEDIAL INVESTIGATION
MINNESOTA POLLUTION CONTROL AGENCY

WATER SUPPLY DISTRIBUTION SYSTEM SCHEMATIC

MALCOLM PIRNIE, INC.

FIGURE 8-1

these two well locations. If ground water flow is assumed to be uniformly eastward beyond Irvine Avenue, it appears that contaminated ground water will not migrate beyond the northerly limits of the new water distribution area. However, it is noted that ground water gradients and directions east of Irvine Avenue have not been investigated directly. Ground water monitoring immediately beyond the northern extent of the municipal potable water service will aid in detecting the movement of contaminated ground water into this area.

9.0 POSSIBLE ALTERNATIVE RESPONSE ACTIONS

9.1 INTRODUCTION

This chapter presents a listing of possible alternative responses to the ground water contamination problem associated with the Kummer Sanitary Landfill. It also presents a discussion of the adequacy of existing data for evaluation of all possible alternative response actions during the feasibility study.

9.2 ALTERNATIVE RESPONSE ACTIONS

The work plan identified various possible alternative response actions. These are presented in Table 9-1. This table also indicates whether the response action is applicable to remediating the source of the problem or ground water contamination beneath the landfill. This remedial investigation was intended to provide information for development of remedial alternatives at the landfill including capping options and leachate control measures. Additional information will need to be collected if it is decided that contaminated ground water downgradient from the landfill (i.e., east of Irvine Avenue) requires remediation. It is assumed that both the landfill contents and unconsolidated material beneath the landfill are contaminated based on the observed impact on ground water quality.

Information regarding stratigraphy, ground water hydrogeology, and contamination have been collected during the initial and supplemental investigations. The data is sufficient to evaluate capping options to eliminate vertical migration of contaminants by controlling surface water infiltration. Removal options are anticipated to be costly, but can be developed with available data. However, the relationship between the base of the filled materials and the ground water table is unknown. If waste material is in contact with the ground water table, horizontal migration of contaminants to ground water will not be mitigated by a capping alternative.

TABLE 9-1

POTENTIALLY FEASIBLE REMEDIAL ALTERNATIVES
KUMMER LANDFILL REMEDIAL INVESTIGATION

Remedial Alternatives	Applicability to Contaminated: Ground Water	Landfill Contents
1. Capping	Yes	Yes
2. Slurry Wall	Yes	No
3. Hydrodynamic Control		
a. Water Table Adjustment Using Pumping Wells	Yes	No
b. Extraction/Injection Wells	Yes	No
c. Extraction/Discharge Wells	Yes	No
d. Extraction Wells/Treatment/ Injection Wells	Yes	No
e. Interceptor Trench	Yes	No
4. Bioreclamation	Yes	No
5. Complete Removal of Waste	Yes	Yes
6. Alternative Water Supply	Yes	No
7. Combination of Alternative	Yes	Yes

Hydrogeologic data at the landfill is adequate to assess alternatives for leachate control. However, the data is not adequate to determine the period of effectiveness of leachate control measures. If waste material is in contact with the ground water table, an indefinite period of operation may be required to protect future ground water quality. If indefinite operation is required, an alternative with high capital costs, such as interceptor trenches, may be preferred over an alternative with high operating costs, such as ground water withdrawal and treatment.

Hydrogeologic data is not sufficient to develop withdrawal alternatives for contaminated ground water downgradient from the landfill. If downgradient withdrawal is required for protection of human health and the environment or compliance with applicable or relevant and appropriate environmental requlations, additional information will need to be collected.

Information collected prior to the supplemental RI do not indicate that soils around the periphery of the landfill are adversely affected. Possible contamination of wetland soils located north and northeast of the landfill due to discharge of contaminated ground water will be determined during Round 6 sampling of the supplemental RI activities. Should soil samples from the wetlands indicate the presence of contaminants attributable to the landfill, additional sampling may be warranted to define in detail the areal extent of soil contamination.

The investigation activities conducted during this RI have not quantified present air quality impacts, if any, due to landfill gas emissions. In Section 6, Air Investigations, it is concluded that ambient air monitoring is not warranted at this time as a means of justifying the need for a landfill cover. The need for a cover or more comprehensive remedial action is justified by ground water data. However, it is noted that consideration is being given to conducting air monitoring prior to installing a cover in order to evaluate the affects of the cover on ambient air quality on a "before and after" basis.

Available environmental criteria for site remedial action were presented in Table 8-1. Possible criteria for ground water remediation are USEPA maximum contaminant levels (MCLs), MDH recommended allowable limits (RALs), USEPA health advisories, and USEPA Ambient Water Quality Criteria. The Resource Conservation and Recovery Act may influence requirements for ground water remediation downgradient from the landfill. Institutional controls to protect against downgradient ground water use may be inconsistent with SARA.

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APPENDIX A

KUMMER SANITARY LANDFILL
INORGANIC WATER QUALITY DATA

Willie Mattison / Larry Olson
Detroit Lakes

3F-00006-01

STATE OF MINNESOTA

Office Memorandum

DEPARTMENT POLLUTION CONTROL AGENCY

TO: Gordon W. Meyer, Chief
Regulatory Compliance Section
Solid and Hazardous Waste Division

THRU: Tom Clark, Head, Ground Water Surveys Unit 5/24

FROM: Don Jakes, Hydrologist DLJ
Program Development and
Facility Review Section

DATE: MAY 24 1982

PHONE: 7-2717

RECEIVED
MAY 28 1982
MN. POLLUTION CONTROL AGENCY
DETROIT LAKES, MINNESOTA

WM	SR
HO	
JM	
FILE	

SUBJECT: KUMMER SANITARY LANDFILL MONITORING DATA (SW-31)

Attached is a compilation of the historical ground-water monitoring data from Kummer Sanitary Landfill as we understand it as of April 30, 1982. Compilation was complicated by:

1. The same names or SWIFMS designators being applied to different wells at various times (unreported to MPCA).

2. Mix-ups in labeling wells on lab data sheets.

3. MPCA records scattered or missing (we don't have lab data sheets for many of the reported analyses from three wells and only have the transcribed SWIFMS data, some of which may also have problems of data being matched to the wrong well numbers).

We think all the data attached are correct, but even so, four more points should be raised.

1. There are only one or two analyses from most of the wells.

2. For the three wells with data dating back to 1971, the analyses are from at least four different labs, Serco (Apparently 1971-1973), Minnesota Valley Testing (MVT on attached sheets, approximately 1974-1978), Bemidji State University (BSU, 1979-1982), and Minnesota Department of Health (MDH, sampling by MPCA 1978-1979 and 1982).

3. Larry Olson of MPCA, Region III reports that many of the wells are in poor condition--missing caps, depressions on the land surface around some well risers, animal fur in one of the wells, turbidity and rust in many, <u>etc.</u>

4. The only water levels that have been measured apparently were those by Kummer's consultant Gerry Sunde in 1980 (three rounds).

Nevertheless, it is possible to make the following observations:

1. The groundwater sampled by Wells 3, C, E, and F has been degraded in quality by leachate from the landfill. Well 3 is the well shown on Sunde's 1980 plans as "Well C," while the current Well C, since 1980, is located approximately 20 feet farther east and is not shown on Sunde's plan.

9000031

MAY 24 1982

For Wells 3 and F there are data before and after the wells became polluted (the pre-1975 data for Well F are on the Well 3 compilation sheet). The increases in chemical oxygen demand (COD), specific conductance (SC), and chlorides (Cl) and the decrease in pH indicate leachate pollution.

For the current Well C, while there has been only one round of sampling, the well is only about 20 feet away from old Well 3, so it is clear that the degraded water quality in the current Well C is of the same leachate origin as in Well 3.

In Well E there also has been only one sample (by MPCA), but the COD, SC, and apparently also Cl are all elevated above the area background levels established by upgradient Wells H and I.

2. The ground water sampled by the Kummer house well has also been degraded in quality to a lesser extent. The trend is visible only in the increase in SC in the 1978-1982 data compared with the 1974-1978 data.

3. In the other downgradient wells, A, B, G, and J, more data should be obtained before trends can be identified. Apparently Well D has never been sampled.

4. Bruce Wilson of your section has raised concern about apparently high total phosphorous levels in wells at the landfill and at the mobile home park farther east of the landfill. Bruce has previously worked on nutrient loading studies of Lake Bemidji for the Water Quality Division, where "high" phosphorous levels were found in the north basin of the lake. Assuming the levels in the ground water at the landfill were orthophosphate (PO_4), they don't represent any health threat, but conceivably might have some effect on P-loading in the lake.

   I have not evaluated this condition, except to note that both the upgradient concentrations (.080 and .170 mg/L in Wells H and I in January 1982) and downgradient concentrations (.028 to 5.66 mg/L in the other wells) are higher than the median total phosphorous concentrations in the ambient ground water in surficial sand aquifers state-wide (.04 mg/L in 79 samples taken 1978-1981. The mean of these 79 ambient samples was higher, 0.24 mg/L, and the range of the ambient P was large, as was the spread--up to 6.22 mg/L with a standard deviation of 0.93 mg/L .)

   I recommend that someone study the phosphorous data more, try to determine the significance of the landfill as a phosphorous source, and project the phosphorous flux rates and nutrient loading rates associated with probable ground-water flow rates in this area, to see if these rates are unusual or important.

Recommendations

1. Additional sampling of the landfill wells so that wells with zero, one, or two samples have more of a track record.

9000032

MAY 24 1982

2. Sampling Wells H, F, C, house, and two additional wells for volatile organics at least once (already accomplished).

3. Get wells properly and permanently field-labeled.

4. Correct well maintenance problems--replace caps, regrade, and divert surface drainage away.

5. Ascertain whether old Well 3 was properly abandoned or simpy bulldozed.

6. Require information on depth of house well and if possible water level elevation.

7. Continue to record condition of water (turbidity, etc.) and if turbid, rusty, or "fur bearing" water is encountered again in Wells B, E, G, I, and J, require replacement of these wells with PVC casings.

8. The total lack of soil borings on the site, except for shallow holes which simply indicated sand to the water table, is unacceptable under present standards. The location, characteristics, and thickness of the "clay" layer inferred to underlie the landfill should be established on the site.

9. The sandy soil, shallow ground water, and elevated specific conductance would make this an ideal site for resistivity surveys to determine the extent of the downgradient plume. Based on this study, it might even be appropriate to install permanent resistivity stations for periodic monitoring of changes in the degraded plume. Other kinds of evaluation of the plume may be appropriate as an alternative, but something more should be done in consideration of downgradient water users.

10. There are no wells downgradient of Well F, which is polluted. Sunde's 1980 measurements indicated ground water flow there was northeastly. A more comprehensive review than I have had time to do should identify whether there are users potentially affected in this direction and whether monitoring farther downgradient to the northeast is needed.

11. Inform Kummer that water elevations must be measured in all on-site wells (not only those sampled) periodically--quarterly for at least one year.

12. The question of final cover should be re-examined--is Kummer capable of or likely to adequately blend sand and organic soil for good vegetation growth? Can parts of the site be final-covered? Are there no better soils available? The current situation, with garbage sitting for a month or more with no cover, and only sand cover and no decent grading on the rest of the site, is sure to promote formation of large volumes of leachate.

cc: Willis Mattison/Larry Olson
Jim Warner/Ken Podpeskar

9000083

Well 3*

60325

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-
8/4/71[A]				2	7.2					0
9/8/71[A]				6	7.7					2
10/5/71[A]				5	7.7					1
11/3/71[A]				1	7.2					1
12/8/71[A]				1	7.7					1
5/2/73[A]				2.7	7.4					0
11/15/73[A]				3.0	7.5		Well "F"			0
8/8/74	MVT	8.4	260	14.8	7.6					0
11/6/74	MVT	17.6	280	17.0	7.3					0
5/7/75		7.2	450	18.4	7.2					0
						?				
11/4/75[A]		6.0	300	4.6	7.5					0
4/6/76	MVT	26.	250	9.2	7.5		Well "3"			2.6
7/6/76	MVT	7.6	240	4.9	7.4					2.4
4/5/78[A]		18.0	500	3.6	7.3					1.0
6/20/78	MDH[B]	35	1100	45.	6.5[f]	630	1.4	.18	4.5	.3
8/10/78	MDH[B]	27	980	28	7.4	560	.5	1.4	2.3	1.0
7/17/79[D]	BSU	86.5	1478.1	95.2	7.1					<1
7/20/79	MDH[B]	93[C]	1600	170	7.0		55.	2.2	3.5	-
8/6/79	BSU	78.2	1402	145	7.0	-				10.3
5/12/80	BSU	93.9	2013	178	6.9					<1.0

abandoned

A = Original data sheets missing (data are from SWIFMS computer data base only).
B = Other parameters also analyzed.
C = T.O.C., not C.O.D.
D = Reported as #2

NOTE: The designator "Well 3" has been used for two or three different wells. The original "Well 3" is the well that was re-named "Well F" by Sunde in 1980. Kummer discontinued using it in 1974 or 1975 and now claims this was done because a former MPCA employee "comtaminated" it. The remainder of the data is for the well Sunde renamed "Well C" in 1980, approximately 600 feet south of "F." A new well "C" was drilled about 20 feet farther east in 1980 when Sunde and Kummer apparently had trouble getting water from the existing well "C."

Kummer House Well (downgradient)

Well "1"

60121

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO-
8/4/71[A]				3	6.8					0
9/8/71[A]				3	7.7					[illegible]
3/8/72[A]				2	7.3					[illegible]
4/12/72[A]				3	7.5					2
5/3/72[A]				5	7.3					2
6/7/72[A]				25	7.0					0
7/11/72[A]				3	7.9					2
5/2/73[A]				2	7.5					2
11/15/73[A]				2	7.6					2
8/8/74	MVT	14.4	300	12.7	7.6					2
11/6/74	MVT	4.4	280	17.6	7.2					1
5/7/75	MVT	1.6	262	7.4	6.9					1
8/4/75[A]		4.0	395	11.3	7.7					0
11/4/75[A]		9.0	400	9.9	7.4					0
4/6/76	MVT	2.8	280	5.6	7.6					1
7/6/76	MVT	3.2	330	5.3	7.5					3
4/6/77	MVT	12	395	8.8	7.8					3
7/7/77	MVT	3.2	300	5.3	7.6					1
4/5/78[A]		37.0	360	4.8	7.4					2
4/19/78	MVT	11.6	530	13.8	7.5					
6/20/78	MDH[B]	7	540	6.1	7.4	300	.13	.007	.14	1
8/10/78	MDH[B]	<5	580	8.7	7.6	300	<.05	<.02	.13	2
7/17/79	BSU	<5	297	<5	7.5					
7/20/79	MDH[B]	<5[C]	530	13	7.5		.18	<.02		
5/12/80	BSU	<5	527	9.3	7.5					1
10/2/80	BSU	<5	453	6.1	7.6					<1
2/23/81	BSU	<5	555	27.8	7.6					1
1/12/82	MDH[B]	<5	560	4.5	7.0[f]	280	<.05	<.02	-	
3/15/82[D]	BSU	5.1	584	7.6	6.8					<1
5/4/83	MDH		600	6.0	6.78[f]	300	95	<20	150	0.
7/7/83		9.8	620	6.3	7.5					<0.

NOTES: A = Original data sheets missing (data from SWIFMS computer data base only).
B = Other parameters also analyzed.
C = TOC, not COD.
D = BSU data sheet identifies as Well D.
f = Field measured, lab result was higher.

000028

Well "A" (1/4 mile downgradient)

60400

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
2/23/81	BSU	<5.0	474	32.0	7.72					<1.01
1/12/82	MDH	1.2	430	1.2	7.0 f	250	2.3	.084	-	-
5/4/82	MDH		390	1.5	6.90 f	330	2800	120	510	<0.C
7/7/83	MDH	8.7	440	1.9	7.7					<0.02

f = field

Well "B" (downgradient)

60500

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-[illegible]
2/23/81	BSU	<5.0	426	20.6	7.75					
1/12/82	MDH	19.	470	4.2	7.0f					<1.01
5/4/82	MDH	—	500	3.3	6.83f	280	5.3	.8	-	-
7/7/83	MDH	6.8	490	4.3	7.7	250	1700	140	890	<0.0[illegible]
										<0.02

f = field

Well "C" (downgradient)

60325

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
1/11/82	MHD	180	2000	200	6.8	940	4.2	3.4	-	-
5/4/82	MHD		1400	190	6.55	1100	21,000	4200	15,800	0.84
7/6/83	MHD	120	2200	180	6.9					1.18

NOTE: Apparently installed in 1980 as a replacement for the Well "C" shown on Sunde's 1980 plans. This more recent well is about 20 feet east of Sunde's "Well C," or about five feet from the east property boundary. For data from the earlier Well C, which until 1980 was called "Well 3", see the "Well 3" data compilation sheet.

Well "D"

60800

Never sampled?

Well "E"

60900

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
1/12/82	MHD	110	920	9.8	7.0f	500	63*	0.8*	-	-
5/4/82	MHD	—	1000	2.9	6.86f	620	18000	330	1400	0.10
7/6/83		13	920	22	7.4					0.07

f = field

* Results probably not accurate for metals because of apparent acidification sediment in analyses (see Well J lab data)

Well "F" (downgradient)

60600 Note: See also 1971-1975? Data on the "Well 3" compilation sheet.

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
1/12/82	MDH	110	1400	75	7.0	620	18.0	.29	-	-
3/15/82	BSU	99.2	1473	157	6.6f					<1.01
5/4/82	MHD	—	1300	87	6.8f	550	21000	300	930	3.14
7/7/83	MHD	67	1200	55	7.1					2.43

NOTE: This is the original well "3" used by Kummer during approximate period 1971-1975. In about 1975, he replaced it with another "Well 3", later renamed well "C" by Sunde in 1980, because, he now alleges, a former employee of MPCA "contaminated" Well F. For 1971-1975 data from Well F see the "Well 3" compilation sheet. It was not sampled approximately 1975-1981.

Well "G" (downgradient or lateral/downgradient)

60700

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
1/12/82	MDH	26.	360	1.2	6.9[f]	200	2.9	.24	-	-
3/15/82	BSU	36.5	433	3.47	7.3					1.14
5/4/82	MDH		370	2.6	~~6.8~~ 6.88[f]	180	2200	120	3200	0.06

f = field

Well "H" (upgradient)

Called "Well 2" at least prior to 1980

60223

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
8/4/71[A]				2	7.2					0
9/8/71[A]				6	7.7					2
10/5/71[A]				5	7.7					1
11/3/71[A]				1	7.2					1
12/8/71[A]				1	7.7					1
1/3/72[A]				3.7	7.1					3
8/8/72[A]				3.0	7.5					2
9/6/72[A]				5.0	7.1					1
10/12/72[A]				4.0	7.5					1
11/8/72[A]				3.0	7.7					1
5/2/73[A]				1.6	7.3					1
11/15/73[A]				3.0	7.6					1
1/5/74[A]				6.0	7.5					3
8/8/74	MVT	10.8	250	13.4	7.5					1.2
11/6/74	MVT	6	230	12.	7.4					0
5/7/75	MVT	0.8	260	6.	7.4					0
8/4/75[A]		17.0	290	10.2	7.7					0
11/4/75[A]		8.0	345	7.4	7.5					0
4/13/76	MVT	2.8	280	7.8	7.3					1.5
7/6/76	MVT	3.6	230	5.6	7.9					1.2
4/8/77	MVT	9.6	250	4.6	7.5					<1
7/7/77	MVT	14.8	55	15.6	7.5					3.2
4/5/78[A]		35.0	415	4.2	7.3					2.0
4/19/78	MVT	2.4	280	4.6	-					<1
6/20/78	MDH[B]	<5	340	.50	7.3	170	.20	<.02	.14	.46
8/10/78	MDH[B]	6	380	.61	7.6	201	.11	<.02	.38	.44
7/17/79[D]	BSU	<5	515	<5	7.4					
7/20/79E	MDH[B]	2.5[C]	330	4.3	7.7		.63	<.02	.33	-
5/12/80	BSU	<5	276	2.48	7.6					1.12
10/2/80	BSU	<5	302	2.29	7.6					4.01
2/23/81	BSU	<5	351	16	7.8					<1.01
1/11/82	MDHB	20	320	<.05	7.2[f]	170	.48	<.02	-	-
3/15/82	BSU	14.11	590	9.82	7.0					<1.01
5/4/82	MDH		330	<0.5	7.0[f]	160	190	<20	150	<0.02
7/6/83	MDH	<5.0	350	0.60	7.7					0.04

NOTES: A = Original data sheets missing (data from SWIFMS computer data base only).
B = Other parameters also analyzed.
C = TOC, not COD.
D = Reported as Well #3.
E = Reported as Well 1-upstream.
f = Field measurement

000036

Well "I" (upgradient)

61000

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
1/11/82	MDH	11	440	<0.5	7.2^f	240	5.5*	.35*	-	-
5/4/82	MDH		380	0.77	6.8^f	220	4500	190	1900	<0.02
7/6/83	MDH	<5.0	300	0.51	7.7					<0.02

f = field

* Results may not be accurate for metals (see Well J lab data sheet)

Well "J"

61300

Date	Analysis by	COD	SC	Cl	pH	Hdns	Fe	Mn	Zn	NO_3-N
1/12/82	MHD	42	570	6.8	6.9f	310	24*	.49*	-	-
5/4/82	MDH		600	7.4	6.76f	330	8600	160	560	<0.02
7/6/83	MDH	5.7	740	10	7.5					0.02

f = field
* Results may not be accurate for metals (See lab data sheet)

APPENDIX B

KUMMER SANITARY LANDFILL
PRIVATE WELLS SAMPLED

REPT12/swm

November 8, 1984

PRIVATE WELLS SAMPLED - NORTHERN TOWNSHIP

Name	Address	Sample #	Sample Date	MDH Adv.	MDH Notice	MPCA Ltr. W/Results
NON-RESPONSIVE [redacted]		130522	5-23-84		X	X
		132233	6-11-84			
		130523	5-23-84		X	X
		132234	6-11-84			
		130524	5-23-84		X	X
		132236	6-11-84			
		130525	5-23-84			X
		132235	6-11-84	X		
		130526	5-23-84			
		130521	5-23-84		X	X
		132237	6-11-84			
		132243	6-11-84		X	X
		13244	6-11-84			X
		13245	6-11-84			X
		132246	6-11-84			X
		132247	6-11-84			X
		130583	7-5-84		X	
		132238	6-11-84			X
		130584	7-5-84	X		
		132239	6-11-84			X
		130575(deep)	7-5-84		X	
		132240	6-11-84			X
		130569	7-5-84		X	
		132241	6-11-84			X
		130570	7-5-84		X	
		132242	6-11-84			X
		130578	7-5-84	X		
		130560(deep)	7-5-84			X
		130561(shallow)				

Name	Address	Sample #	Sample Date	MDH Adv.	MDH Notice	MPCA Ltr. W/Results
NON-RESPONSIVE [redacted]		130562	7-5-84			X
		130563	7-5-84	X		X
		130571	7-5-84			X
		130572	7-5-84			X
		130573	7-5-84		X	X
		130574	7-5-84			X
		130576	7-5-84	X		X
		130577	7-5-84	X		X
		130585	7-5-84			X
		130586	7-5-84	X		X
		130579	7-5-84			X
		130580	7-5-84		X	X
		130581	7-5-84			X
		130582	7-5-84			X
		130565	7-5-84			X
		130566	7-5-84			X
		130567	7-5-84			X
		130568	7-5-84			X
		130607	7-25-84			X
		130608	7-25-84			X
		130609	7-25-84			X
		130610	7-25-84			X

Name	Address	Sample #	Sample Date	MDH Adv.	MDH Notice	MPCA Ltr. W/Results
NON-RESPONSIVE [redacted]		130611	7-25-84			X
		130613	7-24-84			X
		130614	7-25-84			X
		130616	7-25-84			X
		130615	7-25-84			X
						X
		130617	7-25-84			X
		130618	7-25-84			X
		130612	7-25-84			
		130619	7-26-84			X
		130620	7-26-84			X
		130621	7-26-84			X
		130622	7-26-84			X
		130624	7-26-84			X
		130625	7-26-84			X
		130626	7-26-84			X
		130627	7-26-84			X
		130688	10-9-84			
		130689	10-9-84			
		130690	10-9-84			
		130691	10-9-84			

Name	Address	Sample #	Sample Date	MDH Adv.	MDH Notice	MPCA Ltr. W/Results
[redacted]		130692	10-9-84			
		130687	10-9-84			
		130684	10-9-84			
		130685	10-9-84			
		130686	10-9-84			
		130683	10-9-84			

APPENDIX C

KUMMER SANITARY LANDFILL
REMEDIAL INVESTIGATION CHRONOLOGY

APPENDIX C

KUMMER SANITARY LANDFILL
REMEDIAL INVESTIGATION CHRONOLOGY

September 23, 1986	-	Approval of RI/FS Work Plan dated April, 1986 (exclusive of QAPP) by MPCA.
September 29, 1986	-	On-site reconnaissance by Malcolm Pirnie and Stevens Well Drilling Company to inspect proposed monitoring sites.
October 5&6, 1986	-	Delivery of MPCA monitoring well access agreements to property owners in Northern Township.
October 6&7, 1986	-	Vadose zone monitoring conducted.
October 7, 1986	-	Drilling program commenced at monitoring well 5. The boring and well installation progressed through October and was concluded on November 5, 1986. A total of nine borings were drilled and 22 monitoring wells were installed.
November 5, 1986	-	Drilling program concluded.
November 11, 1986	-	Level survey of all monitoring well including previously existing well points concluded by Stewart & Walker, Inc.
November 26, 1986	-	EPA approved QAPP.
December 16&17, 1986	-	Round 1 sampling conducted by PACE Laboratories and Malcolm Pirnie personnel. All Cluster 1-6 monitoring wells were sampled and submitted to CompuChem Laboratories and PACE Laboratories for full HSL analyses and water quality parameter (WQP) analyses, respectively.
January 21, 1987	-	Round 1 analyticals received from laboratories.
January 30, 1987	-	Round 2 Sampling and Analytical Plan submitted to MPCA. It included provisions for resampling of Cluster 1-6 monitoring wells for volatile HSL analyses and the first time sampling of Cluster 7-9 monitoring wells and six residential wells for full HSL and WQP analyses.

APPENDIX C
(Continued)

KUMMER SANITARY LANDFILL
REMEDIAL INVESTIGATION CHRONOLOGY

February 13, 1987	-	Round 1 analytical data validation reported completed and submitted to MPCA.
February 18&19, 1987	-	Round 2 sampling conducted by PACE Laboratories.
March 23, 1987	-	Round 2 analytical data received from laboratories.
April 20, 1987	-	Final Round 3 Sampling and Analytical Plan completed and submitted to MPCA. It included provisions for the resampling of Cluster 7-9 monitoring wells for volatile HSL analyses, eight residential wells for volatile HSL and WQP analyses, and three surface water and three sediment samples for full HSL analyses.
April 28, 1987	-	Round 2 data validation report completed and submitted to MPCA.
April 29&30, 1987	-	Round 3 sampling conducted by PACE Laboratories.
June 12, 1987	-	Round 3 analytical results received from laboratories.
July 13, 1987	-	Round 3 data validation report completed and submitted to MPCA.
July 22, 1987	-	Supplemental RI Scope of Work submitted to MPCA.
October 1, 1987	-	Revised Supplemental RI Scope of Work submitted to MPCA addressing MPCA questions and comments.
November 23, 1987	-	RI Draft Report submitted to MPCA.
January 14, 1988	-	Supplemental RI drilling program commenced and completed by February 12, 1988.
February 16&17, 1988	-	Round 4 sampling conducted by PACE Laboratories.

APPENDIX C
(Continued)

KUMMER SANITARY LANDFILL
REMEDIAL INVESTIGATION CHRONOLOGY

February 23, 1988	-	Pumping test conducted on MW-12B.
March 7, 1988	-	Round 4 analytical data received from CompuChem Laboratories, Inc.
March 22&23, 1988	-	Round 5 sampling conducted by PACE Laboratories.
March 24&25, 1988	-	Slug tests conducted on seven monitoring wells.
April 7, 1988	-	Supplemental RI/FS Scope of Work submitted to MPCA.

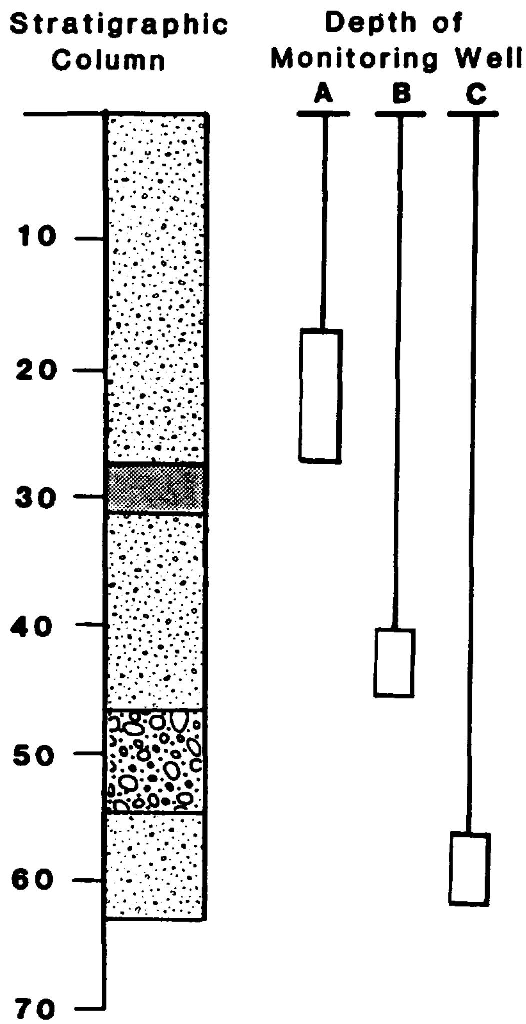
APPENDIX D

KUMMER SANITARY LANDFILL
MONITORING WELL CONSTRUCTION DATA

APPENDIX D

KUMMER SANITARY LANDFILL
MONITORING WELL IDENTIFICATION NUMBERS

Monitoring Well ID	Minnesota Unique Well No.
1A	442479
1B	442480
1C	442481
2A	442482
2B	442483
3A	442484
3B	442485
3C	442486
4A	442487
5A	442488
5B	442489
5C	442490
6A	442491
6B	442492
7A	442493
7B	442494
8A	442495
8B	442496
8C	442497
9A	442498
9B	442499
9C	442500
10A	438194
11A	438193
11B	438192
12B	445479
P-1	445477
P-2	445478
13A	438198
13B	438197
14A	438190
15A	445476
15B	438200
15C	445480



WELL SITE MW-1

Dates of Installation 10/15 - 11/3/86

Elevation (feet above msl)

Ground 1378.4

Well A (TOC) 1379.65

Well B (TOC) 1379.50

Well C (TOC) 1379.65

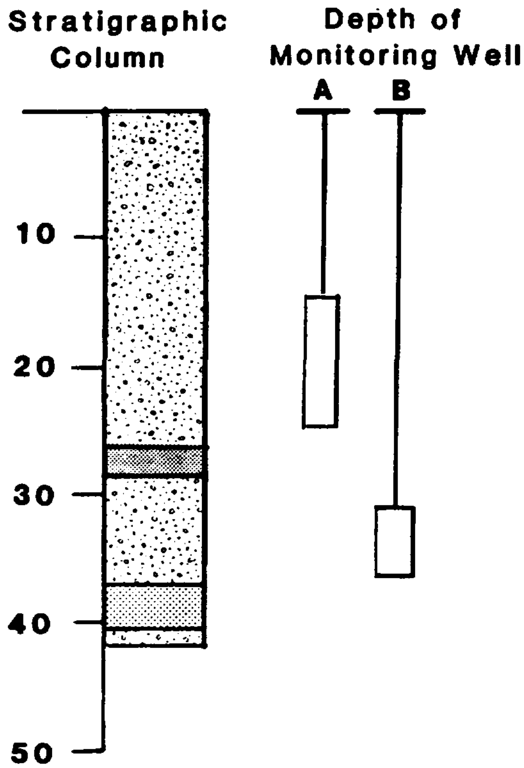
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-2

Dates of Installation 10/27 - 31/86

Elevation (feet above msl)

Ground 1372.0

Well A (TOC) 1373.44

Well B (TOC) 1373.39

Remarks:

Boring for MW-2B was not advanced through till. Sampler was driven through till, and this space was backfilled with bentonite pellets to seal it off.

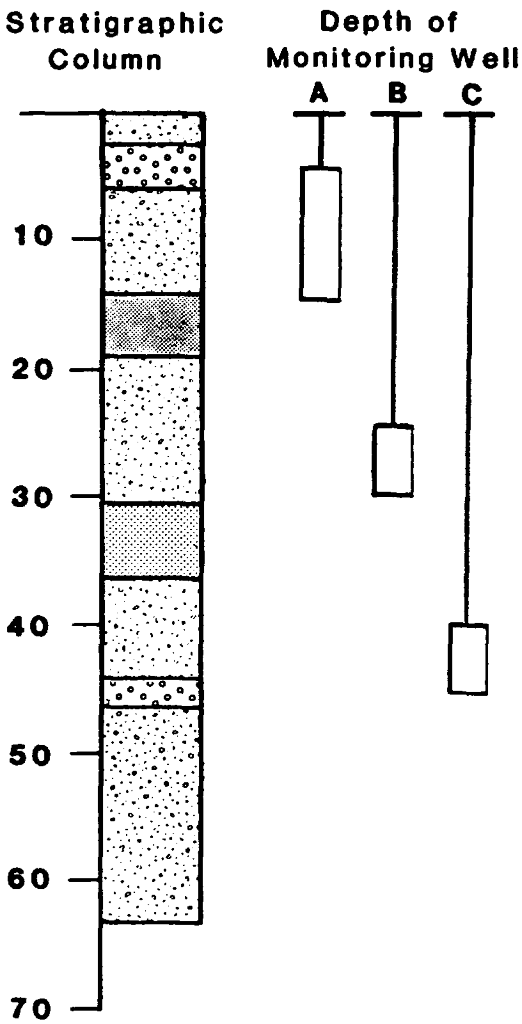
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-3

Dates of Installation 10/26 - 11/3/86

Elevation (feet above msl)

Ground 1366.0

Well A (TOC) 1368.03

Well B (TOC) 1367.58

Well C (TOC) 1367.91

Remarks:

Boring for MW-3C was backfilled with #30 silica sand to the depth of the screen.

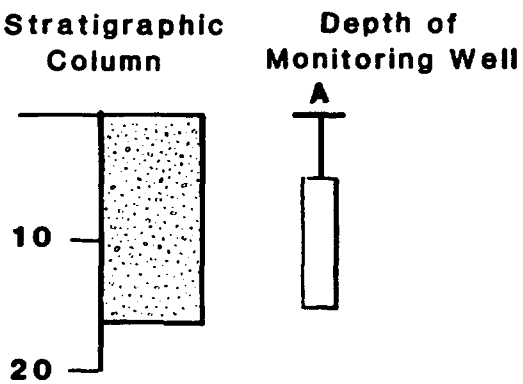
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

MALCOLM PIRNIE



WELL SITE MW4

Dates of Installation 11/5/86

Elevation (feet above msl)

Ground 1365.9

Well A (TOC) 1368.14

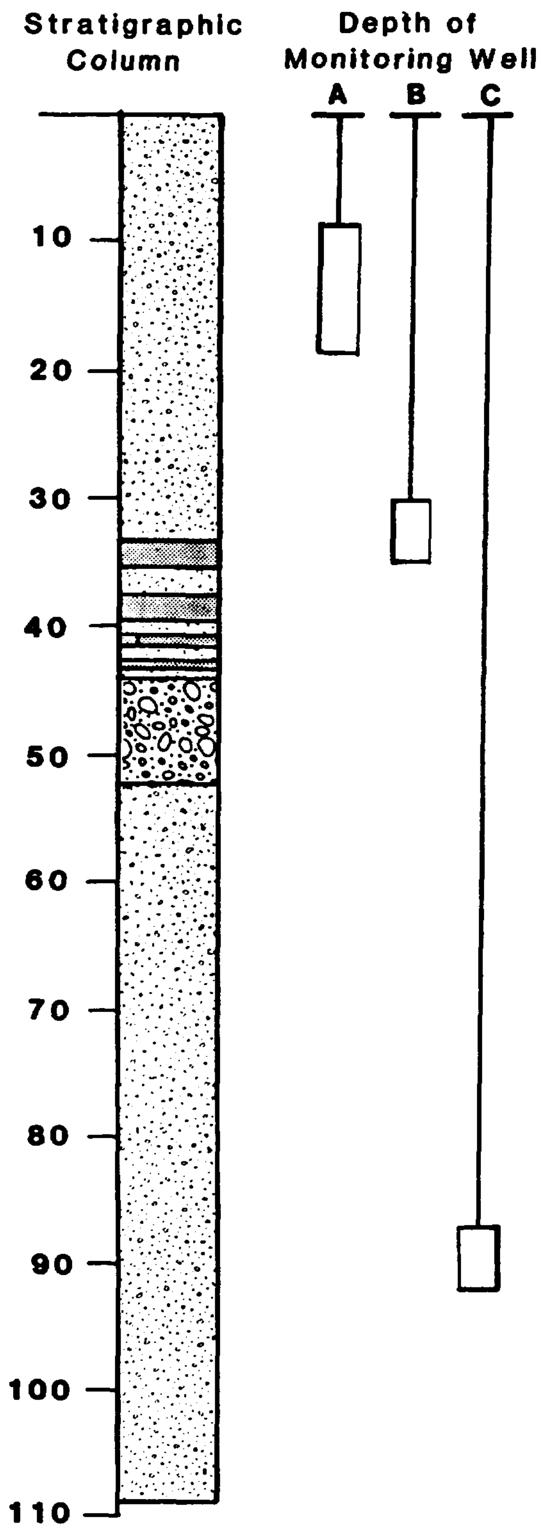
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

MALCOLM PIRNIE



WELL SITE MW-5

Dates of Installation 10/7-10/86

Elevation (feet above msl)

Ground	1371.0
Well A (TOC)	1372.97
Well B (TOC)	1373.32
Well C (TOC)	1372.94

Remarks:

Boring for MW-5C was backfilled with natural collapse to the depth of the screen.

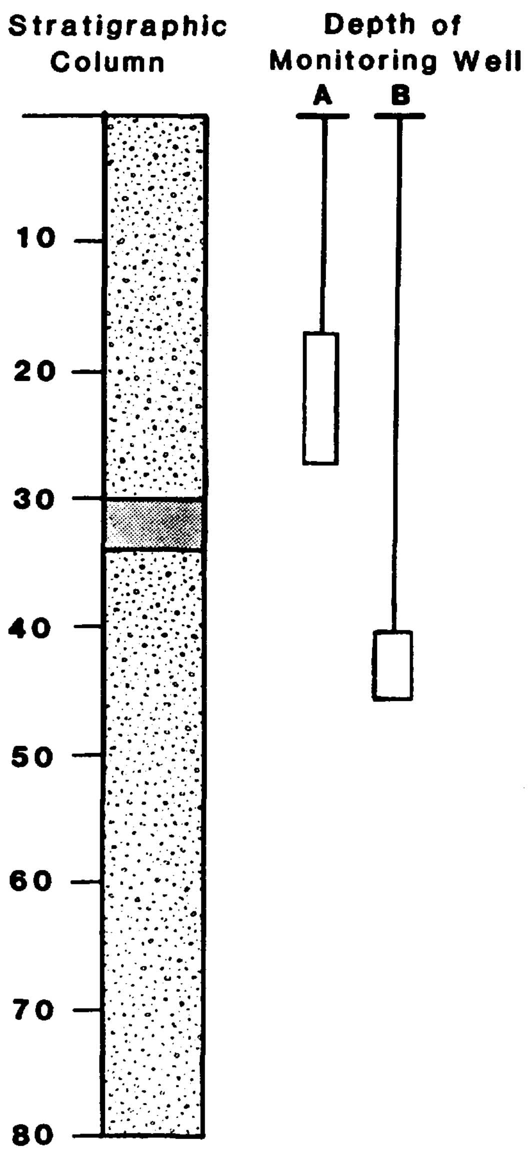
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-6

Dates of Installation 10/28-29/86

Elevation (feet above msl)

Ground	1379.3
Well A (TOC)	1380.86
Well B (TOC)	1380.72

Remarks:

Boring for MW-6B was backfilled with #30 silica sand to the screen depth.

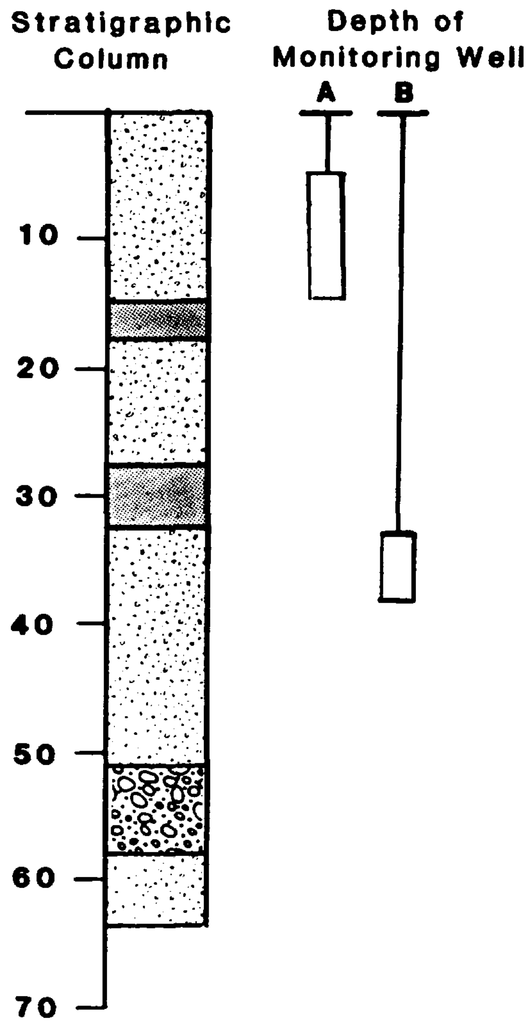
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

MALCOLM PIRNIE



WELL SITE MW-7

Dates of Installation 10/12-14/86

Elevation (feet above msl)

Ground	1354.0
Well A (TOC)	1355.86
Well B (TOC)	1355.96

Remarks:

Boring for MW-7B was backfilled with Portland Cement grout to 48 feet BGL to seal off the till. A 2-foot bentonite pellet seal was placed above the grout. Both wells are sealed with packers to keep water level low enough in the casing to prevent freezing.

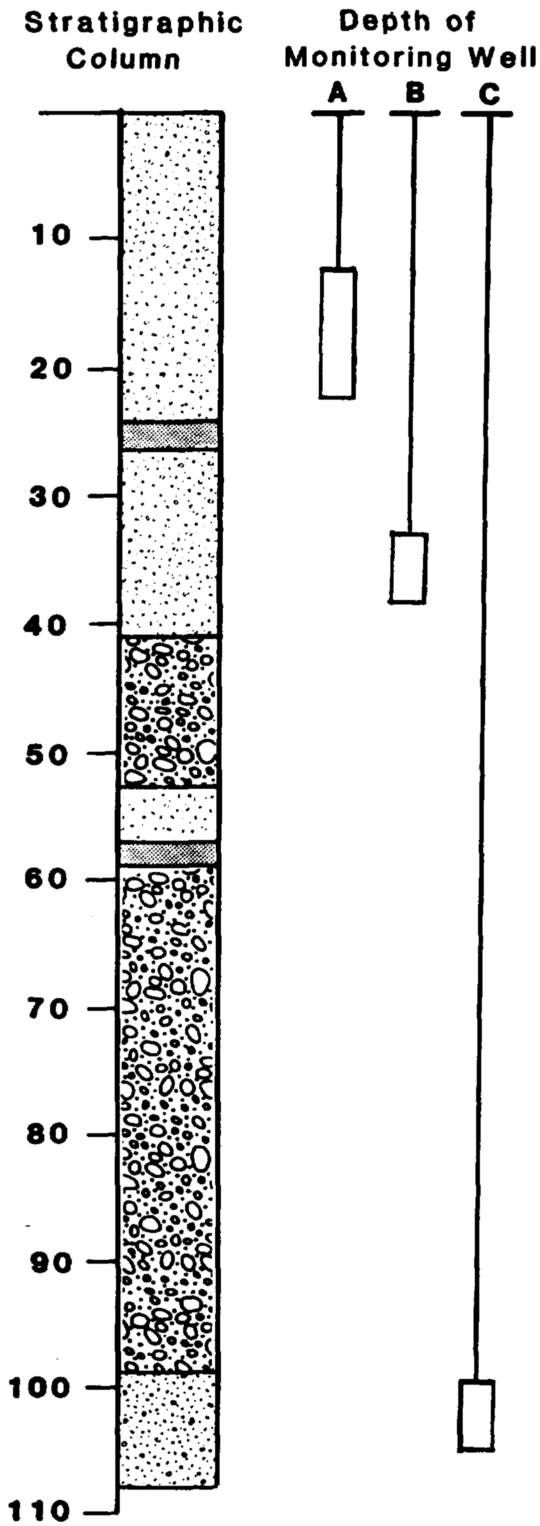
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-8

Dates of Installation 10/20-11/4/86

Elevation (feet above msl)

Ground 1367.8

Well A (TOC) 1369.80

Well B (TOC) 1369.95

Well C (TOC) 1369.59

KEY

Outwash Sand

Clay and/or Silt

Gravel

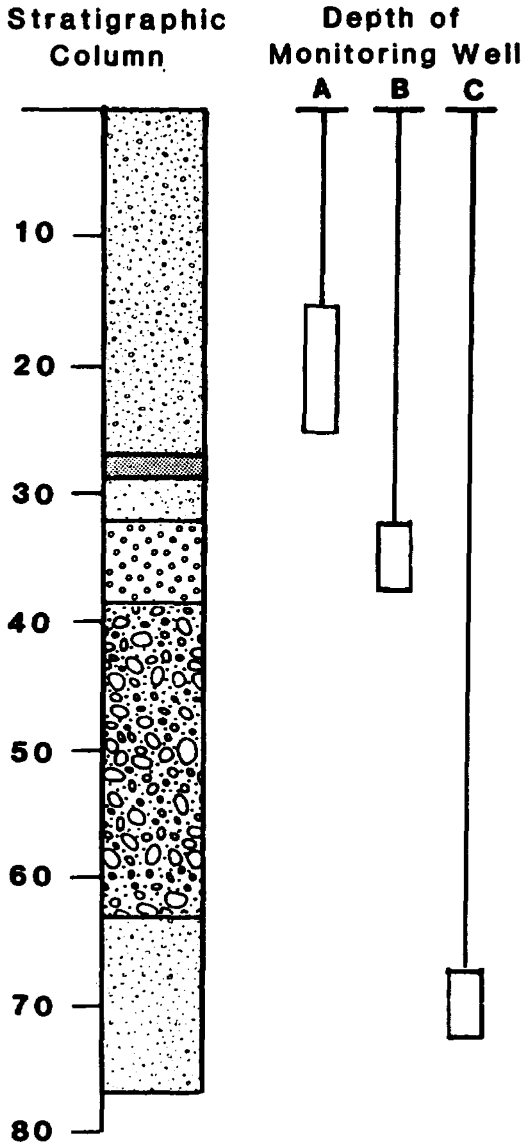
Till (Sand, Clay, Gravel)

Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-9

Dates of Installation 10/24-11/4/86

Elevation (feet above msl)

Ground 1370.5

Well A (TOC) 1372.40

Well B (TOC) 1372.36

Well C (TOC) 1372.33

KEY

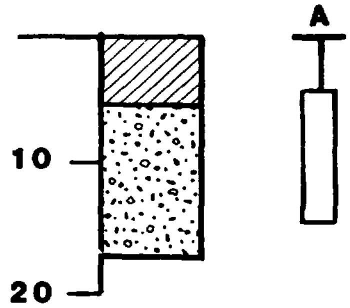
- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

MALCOLM PIRNIE

Stratigraphic Column | Depth of Monitoring Well



WELL SITE MW-10

Dates of Installation 1/18/88

Elevation (feet above msl)

Ground 1352.12

Well A (TOC) 1355.37

Remarks:

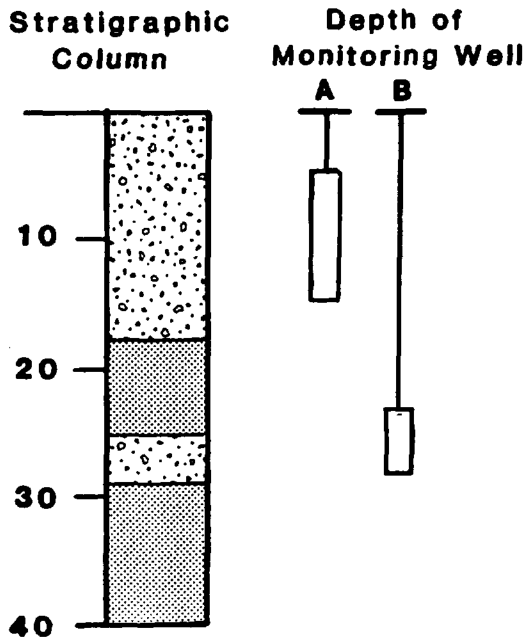
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Muck
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-11

Dates of Installation 1/15 - 1/16/88

Elevation (feet above msl)

Ground 1358.79

Well A (TOC) 1361.93

Well B (TOC) 1361.16

Remarks:

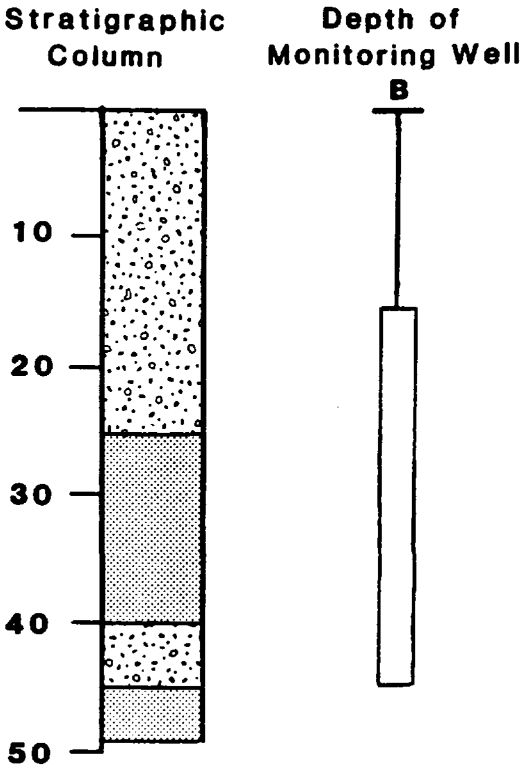
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-12

Dates of Installation 2/2 - 2/3/88

Elevation (feet above msl)

Ground 1374.10

Well B (TOC) 1376.92

Remarks:

Monitoring well MW-12B is constructed of 6" diameter casing and screen. Total screen length is 30 feet. During the pumping test a production rate of 10 gallons per minute was sustained for 24 hours.

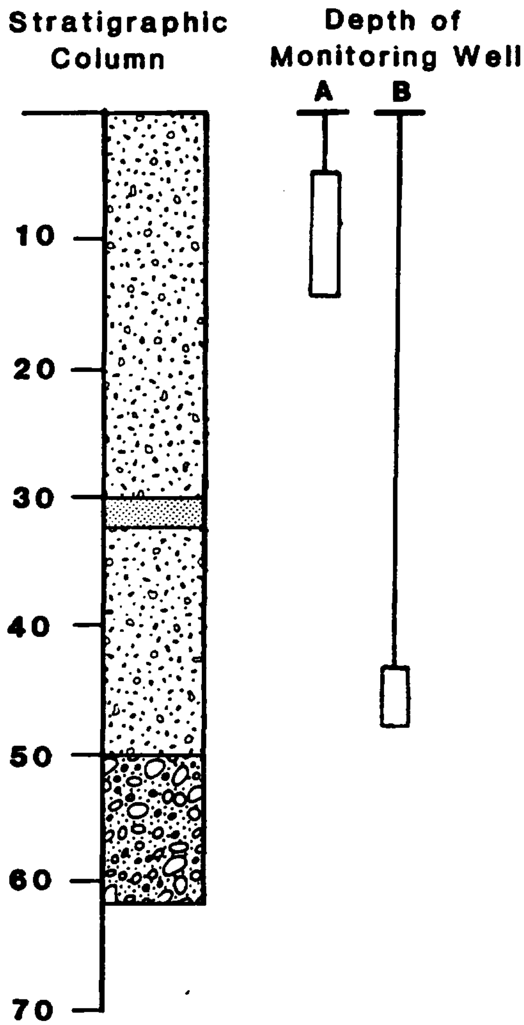
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

MALCOLM PIRNIE



WELL SITE MW-13

Dates of Installation 1/21 - 1/22/88

Elevation (feet above msl)

Ground 1364.05

Well A (TOC) 1367.35

Well B (TOC) 1367.03

Remarks:

KEY

Outwash Sand

Clay and/or Silt

Gravel

Till (Sand, Clay, Gravel)

Screened Interval of Monitoring Well

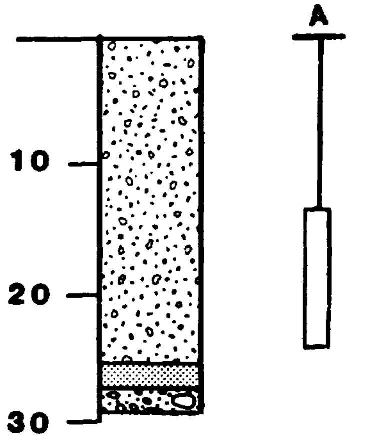
MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

Stratigraphic Column

Depth of Monitoring Well



WELL SITE MW-14

Dates of Installation 1/14/88

Elevation (feet above msl)

Ground 1376.88

Well A (TOC) 1379.06

Remarks:

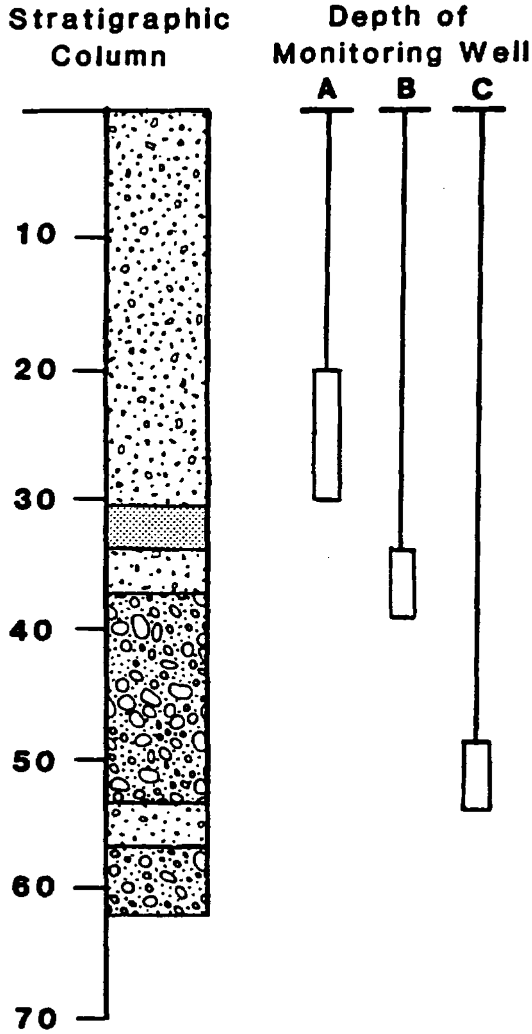
KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MALCOLM PIRNIE

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill



WELL SITE MW-15

Dates of Installation 1/22, 1/26, 1/27, 2/11, 2/12/88

Elevation (feet above msl)

Ground	1374.57
Well A (TOC)	1377.43
Well B (TOC)	1377.48
Well C (TOC)	1377.16

Remarks:

KEY

- Outwash Sand
- Clay and/or Silt
- Gravel
- Till (Sand, Clay, Gravel)
- Screened Interval of Monitoring Well

MONITORING WELL CONSTRUCTION DATA

Kummer Landfill

MALCOLM PIRNIE

APPENDIX E

KUMMER SANITARY LANDFILL
BORING LOGS

:

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1378.34 asl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 1C
DATE: 10-15-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	2/2/3/4	100	dry	loose	10YR 3/4	SAND f-m,some silt,trace organic debris. (SM)	0 ppm HNu
S-2 5.0-7.0	5/8/12/15	50	dry	med. dense	10YR 4/3	SAND f-vc,little silt,grading to 10YR 5/3. (SP)	"
S-3 10.0-12.0	6/6/6/10	40	dry	med. dense	10YR 5/3	SAA. (SP)	"
S-4 15.0-17.0	10/13/16/21	50	dry	dense	10YR 5/3	SAND f-c,trace silt. (SP)	"
S-5 20.0-22.0	12/ / /29	60	dry W.T. @ 22 ft.	dense	"	SAA,grading to SAND f,trace silt. (SP)	"
S-6 25.0-27.0	9/9/12/10	50	moist	med. dense	2.5YR 6/2	SAA,grading to silty CLAY. (SP,CL)	0.1 ppm HNu
S-7 27.0-29.0	5/5/5/7	75	moist	stiff	2.5Y 5/2	SAA,grading to CLAY,plastic. (CL,CH)	0.1 ppm HNu
S-8 29.0-31.0	7/4/5/12	100	moist	stiff	5Y 4/1	SAA,grading to silty CLAY,plastic. (CH,CL)	0 ppm HNu
S-9 31.0-33.0	9/15/21/18	50	wet	dense	2.5Y 4/2	SAND f-vc,trace silt. (SP)	"
S-10 36.0-38.0	12/32/22/17	50	wet	dense	"	SAA,grading to SAND f-vc,some f-m gravel,trace silt and clay.(SW)	0.1 ppm HNu
S-11 41.0-43.0	21/17/19/20	50	wet	dense	"	SAA. (SW)	0.1 ppm HNu
S-12 46.0-48.0	3/3/12/8	50	moist	med. dense	2.5Y 5/2	SAND f-c,and silty CLAY,little f-m gravel. (SW-CL)	0.3 ppm HNu (TILL)

REMARKS: SAA = Same as above
HNu screening performed on samples immediately after opening sampler, with no response.
HNu headspace screening performed on jarred samples 10/21-22; responses are noted under "REMARKS".

* - MUNSELL soil color charts were used for color descriptions.

MALCOLM PIRNIE INC.	PROJECT: KUMMER LANDFILL PROJECT NO.: 0871-03-6003 ELEVATION: 1378.34 msl FIELD GEOLOGIST: ALLISON KOZAK	BORING: 1C DATE: 10-15-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP.REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-13 54.0-56.0	6/14/28/33	30	moist	dense	2.5Y 4/2	SAND f-c,little f gravel,trace silt. (SP)	0.3 ppm HNu

REMARKS: Bottom of boring at 63 ft.

* - MUNSELL soil charts were used for color descriptions.

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1372.03 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 2B
DATE: 10-30-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	2/3/5/5	60	dry	loose	10YR 5/4	SAND f-vc,trace f gravel,silt and debris. (SP)	0 ppm HNu
S-2 5.0-7.0	9/13/13/14	50	dry	med.dense	10YR 5/3	SAND f-vc,trace f gravel and silt. (SP)	"
S-3 10.0-12.0	8/11/11/15	50	wet	med.dense	"	SAA. (SP)	"
S-4 15.0-17.0	5/5/7/11	50	wet W.T. @ 16 ft.	med. dense	5Y 5/1	SAND f-vc,little f gravel,trace silt. (SP)	0.2 ppm HNu
S-5 20.0-22.0	14/9/12/12	50	wet	med. dense	"	SAA. (SP)	0 ppm HNu
S-6 25.0-27.0	17/20/18/22	75	wet moist	dense	5Y 5/2	25-26.0ft SAND f-c,trace f gravel and silt. (SP) 26.0ft-27.0ft SAND f-m,and SILT. (SM)	0.1 ppm HNu 0.2 ppm HNu
S-7 27.0-29.0	23/28/25/28	0.5	slightly moist	dense	"	SAND f,and SILT. (SM)	0 ppm HNu
S-8 29.0-31.0	7/6/9/14	50	wet	med.dense	"	SAND f-c,trace silt. (SP)	0.4 ppm HNu
S-9 34.0-36.0	15/28/18/21	10	wet	dense	"	SAA. (SP)	0.1 ppm HNu
S-10 39.0-41.0	7/9/15/17	100	slightly moist wet	med. dense	5Y 4/1 2.5Y 6/4	39.0ft-40.5ft SAND f-m,and silty CLAY,trace f gravel. (SM-CL) 40.5ft-41.0ft SAND f-c,trace silt. (SP)	0 ppm HNu (TILL) 0.1 ppm HNu

REMARKS: SAA = Same as above.
HNu headspace screening performed on jarred samples.
Bottom of boring at 41 ft.

* - MUNSELL soil color charts were used for color descriptions

BORING: 2B
PAGE: 1 OF 1

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1366.04 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 3C
DATE: 10-26-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	3/3/3/4	90	dry	loose	10YR 4/6	SAND f-c,trace silt and organic debris. (SP)	0.2 ppm HNu
S-2 5.0-7.0	13/15/17/15	50	dry	med.dense	10YR 5/3	5.0ft-6.0ft GRAVEL f-m,little sand f-c,trace silt. (GP) 6.0ft-7.0ft SAND f-c,trace silt. (SP)	0.2 ppm HNu
			W.T. @ 9ft				
S-3 10.0-12.0	5/8/10/12	50	wet	"	5Y 5/3	SAND f-c,trace silt. (SP)	1.0 ppm HNu
S-4 15.0-17.0	8/8/13/20	75	slightly moist	"	"	SAND f,and SILT. (SM)	32 ppm HNu
S-5 17.0-19.0	13/20/15/18	75	"	dense	"	SAA. (SM)	40 ppm HNu
S-6 19.0-21.0	7/8/11/12	50	wet	med. dense	2.5Y 4/4	SAND f-c,trace silt. (SP)	10 ppm HNu
S-7 24.0-26.0	7/7/5/10	50	"	"	5Y 5/3	SAA. (SP)	16 ppm HNu
S-8 29.0-31.0	7/7/6/8	60	moist wet	med. dense	5Y4/1 5Y5/3	29.0ft-30.0ft SAND f,little silt. (SP) 30.0ft-31.0ft SAND f-c,trace silt and f gravel. (SP)	80 ppm HNu
					5Y4/1	SAND f-m, and silty CLAY. (SW-CL)	Wash in sampler (TILL)
S-9 37.0-39.0	58/47/43/46	60	wet	v. dense	5Y5/3	SAND f-c,trace silt and f-m gravel. (SP)	0 ppm HNu
S-10 42.0-44.0	63/78/67/74	60	wet	"	2.5Y5/4	SAA. (SP)	"
S-11 47.0-49.0	23/43/90/95	50	moist	"	5Y6/4	SAND f,trace silt. (SP)	0 ppm HNu
S-12 52.0-54.0	24/27/31/43	70	wet	v.dense	"	SAND f-c,trace silt and f gravel. (SP)	"

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler.

* - MUNSELL soil charts were used for color descriptions.

MALCOLM PIRNIE INC.	PROJECT: KUMMER LANDFILL PROJECT NO.: 0871-03-6003 ELEVATION: 1366.04 msl FIELD GEOLOGIST: ALLISON KOZAK	BORING: 3C DATE: 10-27-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-13 61.0-63.0	21/32/35/29	70	wet	v. dense	5Y6/4	SAND f-c,trace silt and f gravel. (SP)	0 ppm HNu

REMARKS: Bottom of boring at 63 ft.

* - MUNSELL soil color charts were used for color descriptions.

MALCOLM PIRNIE INC.	PROJECT: KUMMER LANDFILL PROJECT NO.: 0871-03-6003 ELEVATION: 1365.91 msl FIELD GEOLOGIST: ALLISON KOZAK	BORING: 4A DATE: 11-05-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0		75	dry		brown	SAND f-c,little silt,trace organic debris. (SP)	0 ppm HNu
S-2 5.0-7.0	9/4/2/2	75	"	loose	"	SAA. (SP)	"
			W.T. @ 8.5 ft				
S-3 10.0-12.0	7/4/3/7	75	wet	loose	"	SAA. (SP)	"

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler.
Bottom of boring at 15 ft.

BORING: 4A
PAGE: 1 OF 1

MALCOLM PIRNIE INC.	PROJECT: KUMMER LANDFILL PROJECT NO.:0871-03-6003 ELEVATION: 1370.95 msl FIELD GEOLOGIST: ALLISON KOZAK	BORING: 5C DATE: 10-07-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	NAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0		100	dry	loose	7.5YR 3/4	SAND f-vc,little silt and organic debris. (SP)	0 ppm HNu
S-2 5.0-7.0	3/5/8/6	100	"	"	10YR4/4	SAND f-vc,little silt. (SP)	"
S-3 10.0-12.0	[illegible]-5/4/[illegible]	100	moist W.T.@ 11.5ft	"	"	SAA. (SP)	"
S-4 15.0-17.0	[illegible]/3/5/6	100	wet	"	"	SAA. (SP)	"
S-5 20.0-22.0	6/8/11/15	100	wet	med.dense	"	SAA. (SP)	"
S-6 25.0-27.0	3/3/2/6	100	"	loose	"	SAA. (SP)	"
S-7 30.0-32.0	6/9/11/13	100	"	med.dense	5Y4/2 2.5Y4/2	30.0ft-30.5ft SAND f,some silty clay. (SC) 30.5ft-32.0ft SAND f-vc,trace silt. (SP)	"
S-8 32.0-34.0	18/10/20/24	100	"	dense	" 5Y5/2 "	32.0ft-33.0ft SAA. (SP) 33.0ft-33.5ft CLAY,some f sand. (CH-SC) 33.5ft-34.0ft SAND f-c,little silt. (SP)	"
S-9 34.0-36.0	7/18/11/14	50	moist wet "	med.dense	5Y4/1 " 5Y4/2	34.0ft-34.5ft CLAY,trace f sand. (CH) 34.5ft-34.7ft GRAVEL f-m. (GW) 34.7ft-36.0ft SAND f-m,little silt. (SP)	"
S-10 36.0-38.0	9/9/7/10	100	wet " " moist	med.dense	" " " 5Y4/1	36.0ft-36.5ft SAA. (SP) 36.5ft-37.0ft GRAVEL f-m,and CLAY. (GC) 37-37.5ft SAND f-c,little gravel,trace silt(SP) 37.5ft-38.0ft CLAY. (CH)	0.2 ppm HNu

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler, with no response.
HNu headspace screening performed on jarred samples 10/11; responses are noted under "REMARKS".

* - MUNSELL soil color charts were used for color descriptions.

BORING: 5C
PAGE: 1 OF 3

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1370.95 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 5C
DATE: 10-07-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-11 34.0-40.0	5/7/7/12	100	moist	med. dense	•	38.0ft-39.0ft CLAY,little f-m sand. (CH-SC)	0 ppm HNu
			wet			39.0ft-40.0ft SAND f-c,and silty CLAY. (SC-CL)	
S-12 40.0-42.0	3/3/5/9	40	moist	med.dense	•	CLAY,little f-m sand. (CL)	•
S-13 42.0-44.0	15/15/13/19	100	•	•	5Y4/2	42.0ft-43.0ft CLAY,little f-c sand and f-m gravel. (CL)	•
					•	43.0ft-44.0ft SAND f-c,some clay. (SC)	
S-14 44.0-46.0	16/22/31/32	50	•	dense	•	SAND f-c,and CLAY,little f-m gravel. (SW-CL)	0.2 ppm HNu (TILL)
S-15 46.0-48.0	23/24/23/29	75	•	•	•	SAA. (SW-CL)	0 ppm HNu (TILL)
S-16 48.0-50.0	33/40/50/72	75	•	v. dense	•	SAA. (SW-CL)	•
S-17 50.0-52.0	95/120/113/131	55	•	•	5Y4/1	SAA. (SW-CL)	•
S-18 52.0-54.0	74/172/103/121	50	wet	•	5Y4/2	52.0ft-52.5ft SAND f-c,some clay. (SC)	0 ppm HNu
			•		•	52.5ft-53.0ft GRAVEL f-c. (GW)	•
			moist		•	53.0ft-54.0ft SAND f-m,little clay. (SC)	0.1 ppm HNu
S-19 54.0-56.0	34/60/75/201	80	•	•	•	SAA. (SC)	0.2 ppm HNu
S-20 56.0-58.0	25/38/53/92	80	wet	•	•	SAND f-m,some clay,trace c gravel. (SC)	0 ppm HNu
S-21 58.0-60.0	27/77/94/115	80	•	•	•	SAA. (SC)	•
S-22 60.0-62.0	26/65/59/52	80	•	•	2.5Y5/4	SAA grading to SAND f-c,little clay and f-m gravel. (SC)	•
S-23 62.0-64.0	24/58/151/197	80	•	•	•	SAA grading to SAND f-m,little clay. (SC)	0.3 ppm HNu

REMARKS:

* - MUNSELL soil color charts were used for color descriptions.

BORING: 5C
PAGE: 2 OF 3

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1370.95 asl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 5C
DATE: 10-07-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-24 64.0-66.0	55/92/135/160	75	wet	v.dense	2.5Y5/4	SAND f-c,little clay and silt and f-c gravel. (SC)	0.2 ppm HNu
S-25 66.0-68.0	42/72/127/148	75	"	"	"	SAA. (SC)	0 ppm HNu
S-26 68.0-70.0	25/39/42/64	75	"	"	"	SAA. (SC)	0.2 ppm HNu
S-27 70:0-72.0	27/49/85/134	80	"	"	"	SAA. (SC)	0.2 ppm HNu
S-28 72.0-74.0	23/32/35/50	50	"	"	"	SAND f-c,trace silt. (SP)	0.2 ppm HNu
S-29 74.0-76.0	36/36/41/46	50	"	"	2.5Y7/4	SAND f-c,little f-m gravel,trace clay and silt. (SW)	0 ppm HNu
S-30 76.0-78.0	36/63/69/121	50	"	"	"	SAA. (SW)	"
S-31 81.0-83.0	39/36/43/91	25	"	"	"	SAND f-c,trace clay and silt. (SP)	"
S-32 86.0-88.0	31/76/121/219	60	"	"	"	SAND f,trace clay and silt. (SP)	0.2 ppm HNu
S-33 91.0-93.0	57/80/61/64	60	"	"	"	SAND f-c,trace silt and f-m gravel. (SP)	0.2 ppm HNu
S-34 96.0-98.0	64/85/216/-	50	moist	"	10YR6/6	SAND f-c,little f-m gravel,trace silt. (SW)	0 ppm HNu
S-35 101-103	40/53/81/110	75	"	"	2.5Y5/4	SAA. (SW)	"
S-36 106-108	72/138/170/-		wet	"	"	SAND f-c,little silt. (SP)	0.2 ppm HNu

REMARKS: Bottom of boring at 108 ft.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 5C
PAGE: 3 OF 3

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1379.24 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 6B
DATE: 10-28-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	2/2/2/3	75	dry	v.loose	10YR4/4	SAND f-c,trace silt,organic debris,and f gravel (SP)	0 ppm HNu
S-2 5.0-7.0	4/4/11/16	60	dry	loose	10YR5/3	SAND f-c,little f gravel,trace silt. (SW)	"
S-3 10.0-12.0	7/14/17/20	50	"	med.dense	"	SAA. (SW)	"
S-4 15.0-17.0	10/10/13/15	60	"	"	"	SAA. (SW)	0.3 ppm HNu
S-5 20.0-22.0	10/10/13/17	60	wet W.T. @ 22 ft	"	"	SAND f-c,trace silt and f gravel. (SP)	0.1 ppm HNu
S-6 25.0-27.0	11/14/22/24	70	wet	dense	"	25.0ft-26.8ft SAA. (SP) 26.8ft-27.0ft SAND f,trace silt. (SP)	0.2 ppm HNu
S-7 30.0-32.0	4/5/10/21	100	moist	med.dense	2.5Y4/4	30.0ft-30.5ft Clayey SILT. (MH)	0 ppm HNu
			"		5Y5/1	30.5ft-31.8ft SILT and CLAY, plastic. (CL)	"
			"		2.5Y4/4	31.8ft-32.0ft Clayey SILT. (MH)	0.1 ppm HNu
S-8 32.0-34.0	9/6/9/18	75	"	"	5Y5/1	32.0ft-33.0ft SILT and CLAY,plastic. (CL)	0.1 ppm HNu
			wet		10YR5/3	33.0ft-34.0ft SAND f-c,trace f gravel and silt. (SP)	
S-9 37.0-39.0	12/19/36/27	50	"	dense	"	SAND f-m,trace silt. (SP)	0.1 ppm HNu
S-10 42.0-44.0	/15+/15+/	50	"	"	5Y5/2	SAND f-c,trace silt and f gravel. (SP)	0 ppm HNu
S-11 47.0-49.0	27/28/32/37	40	"	"	"	SAND f,trace silt. (SP)	0.1 ppm HNu
S-12 53.0-55.0	/30+/30+/	50	"	v.dense	"	SAA. (SP)	0.3 ppm HNu

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler, with no response.
HNu headspace screening performed on jarred samples; responses are noted under "REMARKS".

* - MUNSELL soil color charts were used for color descriptions.

BORING: 6B
PAGE: 1 OF 2

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1379.24 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 6B
DATE: 10-28-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-13 58.0-60.0	12/17/23/34	50	wet	dense	2.5Y5/4	SAND f-c,trace silt. (SP)	0 ppm HNu
S-14 63.0-65.0	16/21/27/32	50	"	"	5Y5/3	SAA. (SP)	"
S-15 68.0-70.0	17/30/40/46	75	"	v.dense	"	SAND f,little silt. (SP)	0.2 ppm HNu
S-16 73.0-75.0	18/21/29/22	40	"	dense	"	SAND f-c,some f-m gravel,little silt. (SW)	0 ppm HNu
S-17 78.0-80.0	19/28/35/43	50	"	v.dense	"	SAND f-m,little silt. (SP)	0.2 ppm HNu

REMARKS: Bottom of boring at 80 ft.

* - MUNSELL soil color charts were used for color descriptions.

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1354.04 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 7B
DATE: 10-12-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	3/3/5/6	50	moist	loose	10YR4/3	SAND f-c,trace silt and organic debris. (SP)	0 ppm HNu
S-2 5.0-7.0	4/6/7/11	50	"	med.dense	10YR5/3	SAND f-c,trace silt. (SP)	"
S-3 10.0-12.0	4/4/3/11	50	"	"	2.5Y6/2	SAA. (SP)	"
S-4 15.0-17.0	15/21/29/18	100	"	dense	5Y5/2	Silty CLAY,trace f-m sand. (CL)	"
S-5 17.0-19.0	3/3/4/3	100	wet	loose	2.5Y5/2	SAND f-c,little silt and f-m gravel. (SP)	"
S-6 24.0-26.0	6/5/5/7	75	"	med.dense	"	SAA. (SP)	"
S-7 29.0-31.0	6/6/7/9	60	moist	"	5Y4/1	CLAY,trace f-c sand. (CL)	"
S-8 31.0-33.0	4/8/16/20	75	moist	"	"	31.0ft-32.5ft SAA. (CL)	"
					5Y5/2	32.5ft-33.0ft SAND f,little silt. (SP)	
S-9 33.0-35.0	7/7/14/18	75	"	"	"	SAND f-m,little silt. (SP)	"
S-10 35.0-37.0	8/8/14/26	50	"	"	"	SAA. (SP)	"
S-11 40.0-42.0	5/7/18/25	75	wet	"	"	40.0ft-41.6ft SAND f,SILT and CLAY. (SC-SM)	"
			moist		"	41.6ft-42.0ft SAND f-m,little silt. (SP)	
S-12 45.0-47.0	7/5/7/10	60	"	"	"	SAND f-c,and SILT. (SM)	"
S-13 50.0-52.0	26/42/56/50	100	wet	v.dense	"	50.0ft-50.2ft SAND f-c,little silt. (SP)	"
			"		"	50.2ft-51.0ft GRAVEL f-c,little silt. (GM)	
			slightly moist		5Y4/2	51.0ft-52.0ft SAND f-c,and silty CLAY,little f-m gravel. (SM-CL)	(TILL)

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler, with no response.
HNu headspace screening performed on jarred samples, with no response.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 7B

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1354.04 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 7B
DATE: 10-12-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-14 61.5-63.5	38/44/50/55	100	wet	v.dense	2.5Y7/2	SAND f-c,little f-m gravel,trace silt. (SW)	0 ppm HNu

REMARKS: Bottom of boring at 61.5 ft.

* - MUNSELL soil color charts were used for color descriptions.

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1367.66 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 8C
DATE: 10-20-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	2/2/3/3	100	dry	v.loose	10YR3/4	SAND f-c,little f gravel,trace silt and organic debris. (SW)	0 ppm HNu
S-2 5.0-7.0	9/10/8/12	70	"	med.dense	2.5Y5/4	SAND f-c,little f gravel,trace silt. (SW)	0.2 ppm HNu
S-3 10.0-12.0	15/21/35/29	70	moist W.T.@ 13.5ft	dense	2.5Y6/4	SAND f-c,trace silt. (SP)	0.1 ppm HNu
S-4 15.0-17.0	17/23/19/7	30	wet	"	"	SAA. (SP)	0.4 ppm HNu
S-5 20.0-22.0	14/12/14/17	70	"	med.dense	"	SAA. (SP)	0.4 ppm HNu
S-6 25.0-27.0	8/15/23/23	100	moist	dense	5Y5/1	25.0ft-26.0ft Silty CLAY,plastic. (CL)	0.3 ppm HNu
					"	26.0ft-26.1ft SAND f-m,little silt. (SP)	0 ppm HNu
					"	26.1ft-26.3ft Silty CLAY,little f-c sand, trace f gravel,plastic. (CL)	"
			wet		5Y4/3	26.3ft-27.0ft SAND f-c,some f gravel,trace silt. (SW)	0.1 ppm HNu
S-7 30.0-32.0	19/14/14/16	70	"	"	5Y5/2	SAND f-c,trace silt. (SP)	0.2 ppm HNu
S-8 35.0-37.0	21/15/17/12	80	"	med.dense	"	SAND f-c,trace f gravel and silt. (SP)	0.3 ppm HNu
S-9 38.0-40.0	18/17/9/10	30	"	"	5Y5/3	SAND f-c,some f-m gravel,trace silt. (SW)	0.2 ppm HNu
S-10 43.0-45.0	6/5/4/6	80	moist	"	5Y5/2	SAND f-c,and silty CLAY,trace f gravel. (SW-CL)	0.1 ppm HNu (TILL)
S-11 48.0-50.0	9/10/42/33	50	"	"	"	SAA. (SW-CL)	0 ppm HNu (TILL)
S-12 53.0-55.0	18/19/14/13	70	wet	"	"	SAA grading to SAND f-m,trace f gravel and silt (SP)	0.1 ppm HNu

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler, with no response.
HNu headspace screening performed on jarred samples 10/21-22; responses are noted under "REMARKS".

* - MUNSELL soil color charts were used for color descriptions.

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1367.66 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 8C
DATE: 10-20-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-13 58.0-60.0	12/7/8/12	100	moist	med.dense	5Y5/2	58.0ft-59.0ft Silty CLAY,plastic. (CL) 59.0ft-60.0ft SAND f-m,and silty CLAY. (SW-CL)	0 ppm HNu (TILL)
S-14 64.0-66.0	12/22/21/22	60	slightly moist	dense	"	SAND f-c,some silty clay. (SW-CL)	0.1 ppm HNu (TILL)
S-15 71.0-73.0	30/20/25/27	50	"	"	"	SAND f-c,some silt,trace f-m gravel. (SM)	0 ppm HNu (TILL)
S-16 76.0-78.0	8/8/9/15	100	moist	med.dense	5Y4/1	SAND f-c,and silty CLAY,trace f-m gravel, plastic. (SW-CL)	"
S-17 81.0-83.0	18/28/37/31	100	"	dense	"	SAA. (SW-CL)	"
S-18 86.0-88.0	7/10/11/20	50	"	med.dense	5Y5/2	SAND f-c,some silt,trace f gravel. (SM)	0.3ppm HNu (TILL)
S-19 91.0-93.0	7/9/13/15	30	"	"	5Y4/1	SAND f-c,and silty CLAY,plastic. (SW-CL)	0 ppm HNu (TILL)
S-20 96.0-98.0	7/7/9/15	100	"	"	"	SAA. (SW-CL)	"
S-21 101.0-103.0	56/57/50/61	70	wet	v.dense	5Y5/2	SAND f-c,some f-c gravel,trace silt. (SW)	0.1 ppm HNu
S-22 106.0-108.0	23/43/67/57	70	"	"	"	SAA. (SW)	0 ppm HNu

REMARKS: Bottom of boring at 106 ft.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 8C
PAGE: 2 OF 2

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1370.49 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 9C
DATE: 10-24-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 0.0-2.0	3/5/8/10	80	dry	med.dense	10YR 3/6	SAND f-c,little f gravel,trace silt and organic debris. (SW)	5 ppm HNu
S-2 5.0-7.0	4/5/10/11	40	"	"	10YR 4/4	SAND f-c,trace silt and organic debris. (SP)	18 ppm HNu
S-3 10.0-12.0	7/7/15/19	40	"	"	10YR 5/3	SAND f-c,trace silt. (SP)	12 ppm HNu
S-4 15.0-17.0	6/9/12/16	50	"	"	"	SAA. (SP)	8 ppm HNu
S-5 20.0-22.0	17/30/29/31	100	WT @ 19ft	v.dense	"	SAND f-m,trace silt. (SP)	3.2 ppm HNu
S-6 25.0-27.0	22/40/35/29	100	moist	"	"	SAA. (SP)	4 ppm HNu
S-7 30.0-32.0	16/20/22/26	80	wet	dense	5Y6/3	SAND f-c,trace silt. (SP)	1.2 ppm HNu
S-8 35.0-37.0	4/7/10/17	50	wet	med.dense	2.5Y4/4	GRAVEL f,trace f-c sand and silt. (GP)	1.2 ppm HNu
S-9 40.0-42.0	14/9/7/6	100	moist	"	5Y4/1	SAND f-m,and silty CLAY,trace f gravel, plastic. (SW-CL)	3.0ppm HNu (TILL)
S-10 45.0-47.0	5/5/5/5	100	"	loose	"	SAA. (SW-CL)	27 ppm HNu (TILL)
S-11 50.0-52.0	5/7/14/23	100	"	med.dense	"	SAA. (SW-CL)	0.8 ppm HNu (TILL)
S-12 55.0-57.0	9/13/17/12		"	"	"	SAA. (SW-CL)	0 ppm HNu (TILL)
S-13 60.0-62.0	4/5/16/19	100	"	"	"	SAA. (SW-CL)	3.4 ppm HNu (15 ppm) (TILL)
S-14 65.0-67.0	20/65/101	50	wet	v.dense	2.5Y5/4	SAND f-c,trace silt and f-m gravel. (SP)	0.4 ppm HNu (150 ppm)

REMARKS: SAA = Same as above.
HNu screening performed on samples immediately after opening sampler; response, if any, is noted in parenthesis under "REMARKS".
HNu headspace screening performed on jarred samples 10/24; responses are noted under "REMARKS". BORING: 9C
* - MUNSELL soil color charts were used for color descriptions PAGE: 1 OF 2

MALCOLM PIRNIE, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

14, 1988

Debra McGovern
t Supervisor
;e Response Section
ound Water and Solid Waste Division
nnesota Pollution Control Agency
!0 Lafayette Road North
t. Paul, MN 55155

Re: Kummer RI Final Report

Dear Ms. McGovern:

We are pleased to submit one unbound and two bound copies of the Kummer Sanitary Landfill Remedial Investigation Final Report. This report addresses the questions and comments in your letter to Mr. John Henningson of December 23, 1987. Information generated during the Supplemental RI has also been incorporated into the report.

Please note that due to the accelerated Supplemental RI and FS schedules, analytical results from sampling Rounds 5 and 6 could not be included in the report. Round 5 was conducted on March 22 and analytical results for it are due within one week. Round 6 is scheduled for the week of May 2. These results and their interpretation will be submitted as a supplement to the report when available.

We have appreciated the assistance of Mr. Stephen Riner in the conduct of this RI. His efforts in resolving many issues have enabled this project to progress well.

If you or your staff have any questions or comments regarding this report, please do not hesitate to call me or Peter Cangialosi.

Very truly yours,

MALCOLM PIRNIE, INC.

Harry G. Bhatt (AKK)

Harry G. Bhatt, P.E.
Project Manager
em
c: J. Henningson, w/attach
C. Michael, w/attach
J. Isbister, w/attach
A. Wojtas, EPA/Reg.V, w/attach
0871-03-6015

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.: 0871-03-6003
ELEVATION: 1370.49 msl
FIELD GEOLOGIST: ALLISON KOZAK

BORING: 9C
DATE: 10-24-86

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-15 70.0-72.0	78/115/112/116	100	wet	v.dense	"	SAA. (SP)	0.2 ppm HNu (50 ppm)
S-16 75.0-77.0	42/47/59/61		"	"	"	SAA. (SP)	0 ppm HNu

REMARKS: Bottom of boring at 77 ft.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 9C
PAGE: 2 OF 2

MALCOLM PIRNIE INC.	PROJECT: KUMMER LANDFILL PROJECT NO.:0871-03-6016 ELEVATION: 1358.79 msl FIELD GEOLOGIST: PHILIP JAGUCKI	BORING: 10A DATE: 01-18-88

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 5.0-7.0		100	W.T. @ 0.6 FT wet	loose	2.5Y2/0	MUCK, decayed organic debris, very soft. (Pt)	
S-2 10.0-12.0	3/3/4/4	100	•	•	7.5YR 5/0	SAND m-f. some m-f gravel. (SP)	
S-3 15.0-17.0	3/4/4/4	100	wet	•	7.5YR 4/0	SAA. (SP)	

REMARKS: SAA = Same as above.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 10A
PAGE: 1 OF 1

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.:0871-03-6016
ELEVATION: 1358.79 msl
FIELD GEOLOGIST: PHILIP JAGUCKI

BORING: 11B
DATE: 01-15-88

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 5.0-7.0	3/3/3/2	100	wet W.T. @ 4 FT	loose	7.5YR 4/2	SAND, m-f. (SP)	
S-2 10.0-12.0	1/2/2/3	50	"	"	7.5YR 5/2	SAA	
S-3 15.0-17.0	3/3/3/3	70	"	"	7.5YR 6/2	SAND, c-m, some f gravel. (SP)	
S-4 20.0-22.0	1/5/7/8	100	moist	med. dense	10YR 6/1	SILT and CLAY, trace m-f sand. (ML)	TILL
S-5 25.0-27.0	3/4/5/5	80	wet	loose	7.5YR 4/2	25.0ft-26.5ft SAND, m-f. (SP) 26.5 ft-27.0ft SAND c-m, some c-m gravel. (SW)	
S-6 30.0-32.0	1/2/2/4	100	moist	med. dense	2.5Y 5/0	CLAY and SILT, trace m-f sand and f gravel. (CL)	TILL
S-7 35.0-37.0	1/2/4/3	80	"	"	2.5Y 5/0	SAA	"
S-8 40.0-42.0	3/4/8/7	0			7.5YR 6/0	(Very fine gray sand retrieved from auger.)	

REMARKS: SAA = Same as above.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 11B
PAGE: 1 OF 1

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.:0871-03-6016
ELEVATION: 1374.10 msl
FIELD GEOLOGIST: PHILIP JAGUCKI

BORING: 12B
DATE: 01-27-88

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR ROD (%)	SAMP. REC. (%)	MAT. MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 5.0-7.0	2/2/4/5	80	dry	loose	10R4/3	SAND c-m with little m-f gravel. (SP)	
S-2 10.0-12.0	5/4/5/6	100	dry	loose	10R5/3	SAND c-m-f. (SP)	
S-3 15.0-17.0	7/6/8/8	100	moist	med. dense	5YR3/3	SAND c-m with trace f gravel. (SP)	
S-4 20.0-22.0	1/2/7/14	100	W.T. @ 19 FT wet	med. dense	"	SAA	
S-5 25.0-27.0	5/6/5/8	100	"	med. dense	10YR5/1 2.5Y5/0	25.0-25.5ft SAND m-f. (SW) 25.5-27.0ft CLAY with trace silt. (CL)	
S-6 30.0-32.0	2/3/4/5	100	moist	med. dense	"	CLAY with some silt. (CL)	TILL
S-7 35.0-37.0	7/7/7/6	100	"	dense	"	SAA	"
S-8 40.0-42.0	5/5/10/14	100	wet	med. dense	2.5Y5/0	SAND m-f	
S-9 45.0-47.0	10/7/6/9	100	"	med. dense	5YR4/3 5Y5/1	45.0-46.0ft SAND c-m, little m-f gravel. (SP) 46.0-47.0ft CLAY. (CH)	

REMARKS: SAA = Same as above.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 12B
PAGE: 1 OF 1

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.:0871-03-6016
ELEVATION: 1364.05 msl
FIELD GEOLOGIST: PHILIP JAGUCKI

BORING: 13B
DATE: 01-20-88

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 5.0-7.0	1/4/2/2	50	dry W.T. @ 4 FT	loose	2.5YR 4/4	SAND c-m-f, little f gravel. (SP)	
S-2 10.0-12.0	1/1/2/3	100	wet	"	5YR4/3	SAA	
S-3 15.0-17.0	1/6/8/9	100	"	"	"	SAA	
S-4 20.0-22.0	3/6/8/8	100	"	med. dense	7.5YR 5/2	SAND c-m, trace f gravel. (SP)	
S-5 25.0-27.0	10/40-5	100	"	loose	" 5YR5/1	25.0-26.5ft SAND m-f. (SP) 26.5-27.0ft SAND f. (SM)	
S-6 30.0-32.0	0/1/6/9	100	"	med. dense	5YR4/2	SAND m-f. (SP) Very thin (1") clay layer near bottom of spoon.	
S-7 35.0-37.0	/0/1/22/29	100	"	"	7.5YR 4/2	35.0-36.5ft SAND c-m, trace f gravel. (SP) 36.5-37.0ft SAND vf. (SM)	
S-8 40.0-42.0	3/8/16/17	100			7.5YR 3/2	SAND c-m and GRAVEL m with trace clay. (GP)	
S-9 45.0-47.0	5/8/8/9	90	"		"	SAA	
S-10 50.0-52.0	10/15/22/20	100	moist		2.5YR 5/0	SILT and CLAY with trace c-m-f sand and f gravel. (CL)	TILL
S-11 55.0-57.0	4/9/12/8	100	"		"	SAA	"
S-12 60.0=62.0	6/12/18	80	wet		5YR5/1	SAND vf with little silt and clay. (SC)	"

REMARKS: SAA = Same as above.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 13B
PAGE: 1 OF 1

MALCOLM PIRNIE INC.

PROJECT: KUMMER LANDFILL
PROJECT NO.:0871-03-6016
ELEVATION: 1376.88 msl
FIELD GEOLOGIST: PHILIP JAGUCKI

BORING: 14A
DATE: 01-14-88

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 5.0-7.0	2/4/6/10	100	moist	loose	2.5YR 2.5/2	SAND m, some m-f gravel. (SP)	
S-2 10.0-12.0	4/9/8/6	100	moist	"	2.5YR 4/2	SAND c-m-f, some m-f gravel. (SP)	
S-3 15.0-17.0	3/4/3/3	100	moist	"	5YR4/3	15.0-16.5ft SAA. (SP) 16.5-17.0ft SAND m-f. (SW)	
S-4 20.0-22.0	4/2/2/1	80	wet	"	10YR4/3 5YR3/4	20.0-21.0ft SAND f. (SW) 21.0-22.0 SAND c. (SW)	
S-5 25.0-27.0	4/4/4/4	100	moist	med.dense	5YR5/1	CLAY and SILT with some sand. (CL)	TILL

REMARKS: SAA = Same as above.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 14A
PAGE: 1 OF 1

MALCOLM PIRNIE INC.	PROJECT: KUMMER LANDFILL PROJECT NO.:0871-03-6016 ELEVATION: 1374.54 msl FIELD GEOLOGIST: PHILIP JAGUCKI	BORING: 15C DATE: 02-11-88

SAMP. NO.& DEPTH (FT)	BLOWS/SIX IN. OR RQD (%)	SAMP. REC. (%)	MAT.MOIST.& W.T. (FT)	SOIL DEN/ ROCK HARD.	COLOR*	MATERIAL CLASSIFICATION (USCS or rock brokenness)	REMARKS
S-1 5.0-7.0	2/2/3/3	100	dry	loose	10R4/3	SAND c-m with some f gravel. (SP)	
S-2 10.0-12.0	2/8/9/9	70	moist	"	7.5YR 6/2	SAND c-m-f with little m-f gravel. (SP)	
S-3 15.0-17.0	5/6/9/9	100	"	"	"	SAA	
S-4 20.0-22.0	5/4/3/4	100	"	"	7.5YR 7/2	SAA	
S-5 25.0-27.0	8/10/13/13	100	wet	med. dense	"	SAA	
S-6 30.0-32.0	4/3/5/5	100	"	"	" 10YR7/3	30.0-31.0ft SAA 31.0-32.0ft CLAY with little silt. (CL)	
S-7 35.0-37.0	2/5/11/17	20	moist	"	2.5Y6/0	SAND vf, some silt and trace of clay. (SC)	
S-8 40.0-42.0	2/2/1/3	100	"	"	7.5YR 5/0	SILT and CLAY, little m-f sand, trace m-f gravel. (ML)	
S-9 45.0-47.0	1/2/2/3	100	"	"	"	SAA	
S-10 50.0-52.0	1/2/2/2	90	"	"	"	SAA	
S-11 55.0-57.0	1/2/2/3	100	"	loose	5YR5/1	SAND, little silt and clay. (SM)	
S-12 60.0-62.0	1/1/2/1	0				(No recovery in split spoon: very fine sand in bottom of auger.)	

REMARKS: SAA = Same as above.

* - MUNSELL soil color charts were used for color descriptions.

BORING: 15C
PAGE: 1 OF 1